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AGRICULTURAL RESEARCH IN EAST AFRICA.

Two recent publications focus the attention of agriculturists on East African problems, and show the forceful manner in which they are being attacked by research methods. The June issue of *Empire Production and Export* is devoted to the Sisal crop, its cultivation, preparation and marketing, a topic appealing essentially to Empire interests no less than to East Africa, which is the world's principal supplier. Another of East Africa's major crops, coffee, receives very special mention in the report of the *Conference on Co-ordination of Agricultural Research and Plant Protection* held early this year at the Amani Research Station, which fittingly served as the *rendez-vous* of workers from all over the territory to discuss co-ordination of research programmes. In both these publications, it is clearly recognised that retrenchment is no cure for the evils which industrial depression has accomplished, rather does it restrict essential development which, aided by scientific research, leads to improvement of the commodity and expansion of markets by the discovery of new uses.

In the very short period, dating from 1925, during which the Sisal industry can be said to have existed, it has had to compete against many adversities. On the production side, methods of planting and cultivation have had to be evolved *de novo*, whilst its utilisation in face of the severe rivalry of Manila Hemp in marine cordage manufacture was a problem in need of the most enthusiastic co-operative effort. This co-operation the industry received wholeheartedly from the Empire Marketing Board which, with the impetus provided by the early experiments of the Imperial Institute, contributed largely to its consolidation and expansion. It is gratifying to know that, since the recent compulsory demise of the Board, the bulk of its activities have been carried on by the Hard Fibres Section of the British Empire Producers' Organisation.

One of the first steps taken towards a wider recognition of Sisal was to standardize its growth, preparation, grading and baling, so that the grades could be recognised and relied on by buyers all over the world. The accomplishment of this task led to very substantial increase in consumption, and furthermore concentrated attention on the production of a fibre which could be spun to still finer counts. This aim now

forms the root of the future policy of Sisal producers, who seek to achieve it by researches in plant breeding and preparation of the fibre.

The plant breeding problem is not circumscribed for, as is well shown in several of the articles under review, production of a fine fibre depends to a considerable extent on cultivation methods about which at present there is very little unanimity of opinion. The recent discovery of a new species of Sisal—*Agave amaniensis* is a promising step towards the evolution of a fine quality fibre-plant, but without further study and experiment, *pari passu* with carefully controlled cultivation trials under a diversity of conditions, its future cannot yet be predicted. The complexity of the issues involved in such experiments is very well illustrated by Mr. A. J. Wakefield's discussion of the controversies over the correct spacing distance and the relative merits of cover-crops as against clean-weeding—two not unrelated problems of immediate significance to the grower. Space unfortunately prevents any discussion of this topic here, but the authoritative contributions dealing with these aspects will amply repay consultation.

It is clear that the Tanganyika planters have realised the importance of elucidating their field and factory problems by proper experimentation, and recently they have given their valued active support by agreeing to pay a cess on all exported Sisal. The proceeds of this fund are to be devoted to the establishment of a Field Experiment Station in the Tanga Province whence the greater part of East African Sisal comes. Experimentation must precede demonstration, and not until the scientific officers of such a station are able to establish indisputable facts can any use come of the suggestion to lay down co-operative experimental plots on various commercial estates.

From the factory viewpoint, the problem of widening the usefulness of Sisal involves the discovery of methods of softening the fibre in such a way as to be able to split it into its finer components, and of a waterproofing process in the production of marine cordage. The achievements and prospects in this important field of investigation are fully dealt with in articles by competent authorities. In particular, the perfection of the softening method using ionised oil in conjunction with suitable mechanical splitting is likely to yield the most far-reaching results inasmuch as it involves the minimum of dislocation in the decorticating machinery now in use. Similarly, experiments on waterproofing show hope of ultimate success, but basic facts are still lacking. The well-known methods employing metallic soaps require proper testing, and the possibility of resins for this purpose is not yet excluded. Softened and waterproofed fibres have of course been produced on an experimental scale, but a large gap still exists between our present knowledge of this subject and its application to commercial needs. Dr. Barker, one of the foremost workers in this field, concludes his article on an optimistic note, but with a plea for starting now to make up the leeway in our fundamental knowledge. Sisal fibre has got to be shown worthy of replacing Manila and Italian Hemps by its superiority; binder twine, through the extended use of the combined harvester-thresher in wheat-growing countries, is no longer an expanding or reliable market; only by research can new uses be found for it suitable for household or industrial conditions.

In so far as the terms of reference of the Conference on Co-ordination of Agricultural Research and Plant Protection included the problems relating to coffee research, the delegates had before them for their consideration the research programmes of the Kenya and Uganda Departments of Agriculture and the Amani Research Station to decide on a suitable allocation of major projects. To the Kenya Department for example were assigned four main problems—(1) Foliar diagnosis of nutrient deficiency, (2) Influence of spraying on liquoring qualities, &c., (3) Rôle of copper in the nutrition of coffee, and (4) Preparation of bean. Whilst this system of division of labour is not intended to preclude other departments or stations from studying local aspects of these problems, it is urged that, where this is necessary, the officers undertaking the work should communicate freely with the specialist on the problem. Unfortunately, the subject could not be completely covered owing to uncertainty as to the programme of the new Coffee Research Station at Lyamangu. This should be forthcoming when the chief officer appointed has had time to familiarise himself with the situation. Meanwhile the Conference had the assurance that the station would be under the control of the Tanganyika Department of Agriculture, who would see that its policy was fully co-ordinated with that of the other centres in East Africa.

Intercommunication of results plays a very essential part in the co-ordination of research, and the Conference was of the opinion that this should be put into effect by the provision of an East African Agricultural Journal, but, until this could materialise, officers should arrange for an interchange of advance typescript copies of annual reports, papers intended for publication, and other relevant matter.

Technical aspects of coffee research did not come within the official purview of the delegates, but an informal meeting was arranged and led to beneficial exchange of views. This took the form of a discussion on technique in field experimentation. Coffee shows high individual variability, but with suitable precautions in eliminating positional influence, and doubtless also by the

use of previous years' records, the number of trees per plot sufficient to prove a 20 per cent. difference is reasonably low. Cultural experiments should, nevertheless, be preceded by uniformity trials, and, in assessing the results, account should be taken of the fact that a high yield increase is often correlated with a distinct falling off in quality. Of interest to others besides coffee investigators was the conclusion that, where shade is essential to the growth of the crop or its effect is being studied, this must be provided as artificial shade, leaving the use of natural shade trees to comparisons of a purely observational nature.

It is to be hoped that this Conference will have the desired effect of preventing duplication of effort, and of crystallizing the main issues of a complexity of problems in the minds of those who, for geographical reasons, must work in comparative isolation.

ARTIFICIAL MANURE BRIQUETTES.

In order to diminish rapid loss of soluble artificial manures or fertilizers, when applied to soils of low water retentivity under conditions of heavy rainfall, many attempts have been made in the past to prepare these substances in granular, tabloid or briquette form. Such materials dissolve very much more slowly in the soil, and their loss, through surface run-off and over-rapid downward leaching and drainage, is thereby diminished.

The latest study of this method of conserving soluble manurial salts added to soil is described in a recent article in *Soil Science*, June, 1934, Vol. 37, No. 6, pp. 445-458, by Dr. F. E. Hance, of the Experiment Station of the Hawaiian Sugar Planters' Association. It deals with a briquette method for reducing losses by leaching of potash manures and for diminishing undesirable fixation of applied phosphates. Briquettes containing potash, nitrogen and phosphates were made by the following formula; dried blood, one part; bone meal, one part; rock phosphate, one part; potassium chloride, one part; Portland cement, two-and-a-quarter parts; sand, one part; and water in sufficient quantity to make a paste. This mixture sets in a few days, and does not disintegrate when placed in water, although its contained potash slowly diffuses out during submersion.

Cement briquettes of this type, weighing about one pound, were found to be very useful for manuring Water-lilies growing in running streams. After one-year's use, the briquette had crumbled to sand, and its place was occupied by a fine mass of small roots. Trials were next made in pot cultures of soil, in which were planted seedlings of Eucalyptus and of Papaw. In the treated cultures, briquettes were placed at the bottom of the pots. After six months' growth the treated plants were much taller and greener than the controls.

Portland cement is not altogether satisfactory for making manure briquettes, because its degree of alkalinity and its lime content are very high, so that certain kinds of manures cannot successfully be incorporated in them. As an alternative, Plaster of Paris was substituted, and the briquettes were coated with paraffin wax to retard disintegration. Briquettes of this sort were tested in pot cultures of sugar-cane with poor soil. One briquette, weighing one pound, was placed at the bottom of a pot containing fifty pounds of soil and one cane cutting. It was tested against a culture containing soil intimately mixed with a finely-crushed briquette, and against another containing no added manure. After three months' growth, the culture containing the solid briquette was much the better of the three.

Subsequent to these successful trials in the laboratory, field tests were next conducted. In order to cheapen costs, a mixture of commercial sodium silicate and pulverised basalt rock was substituted for cement. The new briquette was cylindrical in shape and weighed 115 grammes or four ounces, of which one-half was the weight of the filler and binder. It was compressed by hydraulic pressure into a cylinder, two inches in diameter and about one inch in height. Three hundred such briquettes were placed one foot apart in cane rows, five feet apart, in a field planted with sugar-cane, but no results are recorded. The cost of silicate filler increases the cost of manure by about $17.00 an acre.

In order further to reduce costs, briquettes containing moistened powdered basalt rock alone as binder, were made. When heavily compressed, these were found to set quite hard, and tests are now being conducted in order to compare their efficacy with that of other types, and with granulated materials and ordinary manurial mixtures of equivalent nutrient contents. The cost of the latest pattern of briquette is very little more than that of the contained manures (Ammophos, 24 g.; nitrate of potash 21 g.), since basalt rock is plentiful in the Hawaiian Islands, and the only cost is that of grinding, mixing and compressing.

In order to investigate the type of briquette most suited to the requirements of different crops and different soils, many more tests will have to be performed, since the penetrating ability of roots varies with the growth habits of plants, and the growing period of crops differs widely. Thus, for slow-growing trees, a more resistant and less easily disintegrated briquette will be needed than for quick-growing plants, such as sugar-cane.

F. H.

A NOTE ON THE VALUE OF CORRELATION AND REGRESSION IN STATISTICAL ANALYSIS—*Concluded.*

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The Application of Regression to Statistical Analysis.

In Example VI, in the second last column the arrangement of positive and negative differences is suggestive in that they are not scattered in a random manner; the positive differences are associated with young stools and the negative ones with old stools (*vide* Col. IV, Table I below). It is proposed to use this fact in order to reduce the estimate of the standard error by applying the regression of the difference corrected for age to the statistical analysis.

Example VII.

Table I.

Calculation of the Regression Coefficient.

Age of Stool x	Deviation from Mean Age. d_x.	d_x^2	No. of Canes (by Difference, *i.e.* C–B.) y.	Deviation from Mean Number. d_y.	d_y^2.	Products $d_x \times d_y$.
1	− 2	4	+10	8	64	−16
2	− 1	1	+ 7	5	25	− 5
3	0	0	+ 1	− 1	1	0
4	+ 1	1	− 3	− 5	25	− 5
5	+ 2	4	− 5	− 7	49	−14
Total 15	− 3 + 3 = 0	10	18 − 8 = +10		164	−40
Mean 3			2			

Sum of Squares for x, *i.e.*, for Age = 10.
Sum of Squares for y, *i.e.*, for No. of Canes by difference = 164.
Sum of Products, xy = − 40.

$$\text{Regression Coefficient, } b_{y.x}, \textit{ i.e.}, \text{ for No. of Canes corrected for Age} = \frac{\text{Sum of Products xy.}}{\text{S.S. x,}}$$

$$= \frac{-40}{10} = -4.$$

The next step is to apply this value of b to calculate the average number of canes for each age as determined by regression, and then use the sum of squares of the difference between this average value and the recorded value in order to test the significance of the mean difference. From first principles,

$$\mathbf{Y} = M_y + b\,(x - M_x)$$

Therefore, substituting the appropriate values,

$$\mathbf{Y} = 2 + (-4)(x - 3)$$
$$= 14 - 4x$$

Table II.

Calculation of Sum of Squares by Regression.

Age of Stool. x	Average No. of Canes for each Age, *i.e.* $\mathbf{Y} = 14 - 4x$.	No. of Canes y	y − **Y**.	(y − **Y**)²
1	+10	+10	0	0
2	+ 6	+ 7	+1	1
3	+ 2	+ 1	− 1	1
4	−2	−3	− 1	1
5	−6	−5	+1	1
Totals	+10	+10	0	4

The total of the last column represents the sum of squares of the differences between the cane numbers and their average value as determined by regression.

As one degree of freedom has been used up in calculating the constant, b, the number of degrees of freedom is only three and the standard error of the mean difference in number of canes

$$= \sqrt{\frac{4}{3 \times 5}} = .52$$

The value of t for three degrees of freedom and P = .05 is 3.182. A mean difference greater than 3.182 × .52 = 1.65 is significant, proving that the mean difference of two is definitely significant.

The advantage in this example is particularly marked as high differences in stool C are associated with low ones in stool B.

$$\left.\begin{array}{l}\text{Actually, the}\\ \text{Standard Error of}\\ \text{the Regression}\\ \text{Coefficient, b}\end{array}\right\} = \sqrt{\frac{\text{Variance (y − Y)}}{\text{S.S. x}}}$$

$$= \sqrt{\frac{4}{\frac{3}{10}}}$$

$$= .37$$

$$\left.\begin{array}{l}\text{The calculated}\\ \text{value of } t \text{ for the}\\ \text{regression co-}\\ \text{efficient, } b_{y.x}\end{array}\right\} = \frac{b_{y.x}}{\text{S.E. of } b_{y.x}} = \frac{-4}{.37} = -10.8$$

The chances of this regression function being significant are therefore well over 100 : 1, as the reading from the table of t for three degrees of freedom and P=.01 is only 5.841.

This method of applying the regression coefficient to the analysis should only be used when the independent factor in the regression—in this example, the age—does not vary from sample to sample of the dependent factor, *i.e.*, the cane-number. It should also be remembered that, in small samples particularly, the fact that one degree of freedom is used up in calculating b will often eliminate any advantage accruing from the application of regression in the statistical analysis. It is therefore important to choose the method of analysis which gives the most conclusive results from the treatment comparisons it is desired to make.

Alternative Methods of Computation.

While the system detailed above of estimating the standard error using regression is probably the one most easy to comprehend, the working out is unnecessarily laborious. There are various ways in which the amount of the arithmetic involved can be greatly reduced, by methods similar to those described in the analysis of variance of yield trials. It is proposed here to apply the "Variable-squared" method to the example just concluded.

Table III.

Calculation of the Regression Coefficient.

Age of Stool in Years.	x^2	No. of Canes (by Difference *i.e.*, C – B) y.	y^2	xy.
1	1	+10	100	+10
2	4	+ 7	49	+14
3	9	+ 1	1	+ 3
4	16	−3	9	−12
5	25	−5	25	−25
Totals 15	55	+10	184	−10
Correction Factors	$\frac{15^2}{5}=45$		$\frac{10^2}{5}=20$	$\frac{\Sigma x \times \Sigma y}{n}=\frac{15\times 10}{5}=30$

S.S. x *i.e.*, S.S. for Age = 55 − 45 = 10 having 4 degrees of Freedom.
S.S. y *i.e.*, S.S. No. of Canes = 184 − 20 = 164 do. do.
S.P. xy *i.e.*, Sum of Products = − 10 − 30 = − 40 do. do.

(*N.B.—In applying the correction factor to estimate the sum of products it is essential to record the signs + or −. If the correction factor is negative, it has to be added to the sum of xy in computing the sum of products.*)

The Regression Coefficient of y corrected for x *i.e.* $b_{y.x} = \frac{-40}{10} = -4$.

Then the required regression sum of squares for (y−**Y**) can be obtained from the equation given by Fisher.

S.S. (y−**Y**)=S.S. y−$b_{y,x}^2$ × S.S. x.

where **Y**=the average value of y for each value of x determined by the regression coefficient of y corrected for x.

$$\therefore \text{S.S.}(y-\mathbf{Y}) = 164-(-4^2)\times 10$$
$$= 164-160$$
$$= 4$$

In this example, b is exactly−4, and the sum of squares is identical to that calculated by the original method. Where b is only an approximation, it is important to take its calculation to several places of decimals, as, in using the above equation, a slight error in the value of b^2 will lead, in analysis where the S.S.x is large, to a considerable discrepancy in the final estimate of the S.S. (y−**Y**).

Still a third method of estimating the S.S. using regression, is to calculate for the corresponding readings of x and y, the value of y−bx, and use the dispersion of these values to work out the desired standard deviation. This calculation is given in Table IV, taking b = − 4, as previously calculated.

Table IV.

Sum of Squares of (y-bx).

y	x	bx	y–bx	Deviation of y–bx from its Mean.	Deviation².
+10	1	− 4	14	0	0
+ 7	2	− 8	15	+ 1	1
+ 1	3	−12	13	− 1	1
− 3	4	−16	13	− 1	1
− 5	5	−20	15	+ 1	1
Totals ..	—	—	70	—	4
Mean ...	—	—	14	—	—

The penultimate column shows the values of $(y-Y)^2$ as originally calculated.

The Utility of Uniformity Trials in Field Experiments.

One of the chief difficulties in obtaining conclusive results from field trials is the great variation in soil and environmental fertility from plot to plot. Modern methods of lay-out combined with an appropriate statistical analysis have greatly reduced the effects of this soil heterogeneity on the final interpretation of results. Even to-day, however, in many correctly designed experiments, the plot variation is often sufficiently great to mask the real yield differences between the treatments under comparison. In consequence, it has been suggested that a semi-permanent plot lay-out might be adopted, and the potential yielding ability of each plot determined by one or more uniformity trials. In computing results from succeeding experiments, the relative yielding capacity of the plots as ascertained from the uniformity trials might then be used in the statistical analysis of the data. Available data to show the advantages or disadvantages of such a procedure are very limited. The number of uniformity trials required, the type of crop or crops that should be used, the variation in the inherent fertility of a plot from year to year, and the best method of applying previous records to the analysis are still matters of conjecture. Furthermore, uniformity trials entail a considerable outlay in both time and money on non-productive research. If they are to be of practical value, they must show, when the results are applied to subsequent experiments, a marked advantage over ordinary field trials; this advantage must endure for a sufficient number of years to offset the original outlay. It is possible that for long range research on perennial crops, in which the plots and crops are of necessity of a semi-permanent nature, the data from preliminary uniformity trials may help considerably in overcoming many of the existing difficulties in obtaining any conclusive results. Judging from the rather scant information available, the use of uniformity trials in connection with short season annual crops does not show great promise. One reason for this is that subsequent experimental treatments and changes in crop will very soon vitiate the validity of the preliminary trials as a measure of the potential plot fertility. The present information regarding the utility of uniformity trials is, however, really too limited to permit of any authoritative statement about their value to the experimentalist.

Statistical Methods.

In experiments in which the crop and the yield records throughout the uniformity and experimental periods remain the same, statistics may be applied to the actual data. In other trials in which the preliminary determination of soil fertility values has been determined from several different crops, or in which the subsequent crops or the ultimate experimental units of measurement are altered, it will be necessary to record all yields as a percentage of the mean yield for any given experiment or series of experiments.

In utilising uniformity trials in the analysis of variance, the method which at once suggests itself as being both simple and effective is to use, not the plot yields, but the difference between the experimental yield for any plot and its mean yield as determined in the uniformity trials. It has been shown already in Example IV, that such a method under certain circumstances will provide a relatively low yet valid estimate of the standard error.

Consider the following simple experiment in which two varieties of potato, A and B, are being tested on plots whose relative yielding capacity has been ascertained by a preliminary uniformity trial. The experiment consisted of eight 1/40th acre plots arranged in four randomised blocks.

EXAMPLE VIII.

Table I.—Plot yields quoted in bushels.

Serial No. of Plot.	Block No.	Yield in Uniformity Trial. x	Experimental Yield. y	Variety in Experiment.	y−x.
1	1	7	12	A	+5
2		7	5	B	−2
3	2	4	3	B	−1
4		2	8	A	+6
5	3	4	11	A	+7
6		6	3	B	−3
7	4	3	9	A	+6
8		11	9	B	−2
Totals		44	60		+24 −8 = +16
Means		5·5	7·5		2

Table II.—Yields by Difference between Experimental and Uniformity Trial.

Block.	Variety A.	Variety B.	Block Totals.
1	+5	−2	+3
2	+6	−1	+5
3	+7	−3	+4
4	+6	−2	+4
Variety Totals	+24	−8	Grand Total 16

$$\text{Total SS.} = 5^2+6^2+7^2\ldots(-3)^2+(-2)^2-\frac{16^2}{8} = 164-32 = 132$$

$$\text{Block SS.} = \frac{3^2+5^2+4^2+4^2}{2} - \frac{16^2}{8} = 1.$$

$$\text{Treatment SS.} = \frac{24^2+(-8)^2}{4} - \frac{16^2}{8} = 128.$$

$$\text{Error SS.} = 132-(1+128) = 3.$$

Table III.—Analysis of Variance.

Due to	Sums of Squares.	Degrees of Freedom.	Variance.
Total ..	132	7	..
Block.. ..	1	3	·3
Treatment ..	128	1	128
Error ..	3	3	1

The mean difference in yield between the uniformity and experimental trials is 2 bushels. The standard error of this is $\sqrt{\frac{1}{8}} = \cdot 35$

t by calculation $= \frac{2}{\cdot 35} = 5.71.$

The reading of t from Fisher's table for n=3 and P=.05 is 3.182, showing that the yields in the experiment have increased significantly over those in the uniformity trials. The experiment was not designed to ascertain whether the uniformity or the varietal trial gave the best yields. It was primarily a comparison of the two varieties A and B, and the analysis of variance table does provide this additional and more essential information. The z test shows that treatment variance is significant when compared with error variance. It is possible therefore to use this error variance to test whether there is any real difference between the values of **y—x** for the two varieties A and B.

A difference between variety totals of y—x greater than $\sqrt{1\times4\times2\times3.182} = 9.0$ is significant. The difference between treatment totals of y-x is 32, proving that Variety A is definitely superior to Variety B. The probability of significance in this comparison is greatly in excess of 100 : 1.

If the statistical analysis had been limited to the experimental yields alone the calculated value of z for treatment and error variances works out at 1.0329 and the corresponding reading of z for P=.05 at 1.1577. Therefore, by this direct method of analysis, it would not be possible to prove statistically that the difference between treatments is a significant one, even though this difference in the above example is relatively large. The application of the uniformity trials to the foregoing analysis has been of undoubted advantage. This is due to the fact that once the effects of treatment and block arrangement have been eliminated in the analysis of variance, there is a distinct positive correlation between the yield of any plot in the uniformity and experimental trials. Plots which give good yields in the preliminary trial, also show relatively heavy yields in the experiment. If, however, the correlation had been small or negative, the standard error from y−x would have been greater than that from y alone. In Example IX, the same yield data have been rearranged so that high yields in the uniformity trial tend to correspond with low yields in the experiment. There still exists a close association between the plot yields in the uniformity and experimental trials, but in this case the correlation is negative. With perennial or orchard crops particularly, such a correlation is by no means uncommon, as in many cases individual trees or plots which have yielded highly in one year become temporarily exhausted and require a reasonable period for recuperation.

EXAMPLE IX.

Table I.—Yields in Bushels per plot of a Uniformity Trial (x) and a Variety Trial (y) of Potatoes.

Block	Variety A.		Variety B.		Block Totals.	
	x	y	x	y	x	y
1	2	12	7	3	9	15
2	3	11	4	9	7	20
3	4	9	11	3	15	12
4	7	8	6	5	13	13
Totals	16	40	28	20	44	60

Once again, the treatment effects can be assessed either from the analysis of the plot yields, y, in the varietal trial itself, or from the analysis of the difference between the plot yields in the experimental and in the uniformity trial, *i.e.*, of y-x. Application of these two methods to the above data shows that when the experimental yields alone are considered the chances of proving a significant difference between the two varieties are almost 20 : 1. If, however, the data from the uniformity trial are used in the analysis as in Example VIII the probability of significance drops to about 10 : 1.

There has therefore been a decided loss of accuracy in basing the analysis on y − x instead of on the plot yields themselves. Sanders (4) suggests that the analysis of variance should be based on y − bx, where b is the regression coefficient of y corrected for x, *i.e.*, of experimental yields corrected in accordance with the corresponding plot yields in the uniformity trial. In this event, provided there is a definite correlation, + or −, between the plot yields in the two trials, there is every possibility of obtaining a lower yet valid estimate of the standard errors. The advantage or disadvantage of such a method will depend on the extent to which the yields in the preliminary trials determine the true potential yielding capacities of the plots. In cases, where the correlation is slight, there will almost certainly be a loss of accuracy, as one degree of freedom is used up in calculating the regression coefficient, b. The error variance in such a regression analysis determines the distribution of the values of y − bx, and the significance of differences between treatments will be based on the difference between treatment values of y − bx, and not between the actual treatment yields in the experiment. The method of using the regression coefficient to determine the analysis of variance is shown below, the yield data from the preceding Table being used.

Table II.—Analysis of Variance of x (Uniformity Trial).

Due to	Sums of Squares.	Degrees of Freedom	Variance.
Total	$2^2+3^2+4^2 \ldots\ldots 11^2+6^2-\frac{44^2}{8}=300-242=58$	7	
Blocks ..	$\frac{9^2+7^2+15^2+13^2}{2}-242 \quad = 20$	3	6.67
*Treatment ..	$\frac{16^2+28^2}{4}-242 \quad = 18$	1	18.0
Error ..	$58-(20+18) \quad = 20$	3	6.67

Table III.—Analysis of Variance of y (Experimental Trial).

Total	$12^2+11^2+9^2 \ldots\ldots 3^2+5^2-\frac{60^2}{8}=534-450=84$	7	
Blocks ..	$\frac{15^2+20^2+12^2+13^2}{2}-450 \quad =19$	3	6.33
Treatments ..	$\frac{40^2+20^2}{4}-450 \quad =50$	1	50.0
Error ..	$84-(19+50) \quad =15$	3	5.0

* In the Uniformity trial, treatment differences are non-existent, and in consequence the treatment variance is that due to the grouping of plots in accordance with the treatments allocated to them in the succeeding experiment.

Just as in the analysis of variance of x and y, the sum of squares has been split up into its component parts, so, by exactly similar methods the total covariance should be apportioned in accordance with the amounts attributable to Blocks, Treatments and Residual. The analysis of covariance for Example IX is therefore as follows :—

Table IV.—Analysis of Covariance.

Due to	Sums of Squares.	Degrees of Freedom.	Covariance.
Total ..	$2\times12+3\times11+4\times9\ldots11\times3+6\times5-\frac{44\times60}{8}=269-330=-61$	7	
Blocks ..	$\frac{9\times15+7\times20+15\times12+13\times13}{2}-330 \quad =-18$	3	-6.0
Treatments	$\frac{16\times40+28\times20}{4}-330 \quad =-30$	1	-30.0
Error ..	$-61-(-18-30) \quad =-13$	3.	-4.33

$$\text{Regression Coefficient, b, for y corrected for x} = \frac{\text{Covariance Error}}{\text{Error Variance of x.}} = \frac{-4.33}{6.67} = -.65$$

Table V.—Analysis of Variance of y – bx.

	Variety A.			Variety B.			Block Totals for y – bx.
	x	y	y – bx	x	y	y – bx	
1	2	12	13.30	7	3	7.55	20.85
2	3	11	12.95	4	9	11.60	24.55
3	4	9	11.60	11	3	10.15	21.75
4	7	8	12.55	6	5	8.90	21.45
	—	—	50.40	—	—	38.20	88.60

		Degrees of Freedom.	*Variance.*
Total S.S. $=13.3^2+12.95^2\ldots10.15^2+8.90^2-\frac{88.6^2}{8}$	$=29.2$	6*	
Block S.S. $=\frac{20.85^2+24.55^2+21.75^2+21.45^2}{2}-\frac{88.6^2}{8}$	$=4.05$	3	1.35
Treatment S.S. $=\frac{50.4^2+38.2^2}{4}-\frac{88.6^2}{8}$	$=18.6$	1	18.60
Error S.S. $=29.20-(4.05+18.60)$	$=6.55$	2	3.28

* One degree of freedom has been used in calculating the regression coefficient.

The z test applied to this analysis to compare treatment and error variances shows a non-significant difference between treatments. There is actually a loss of precision when this method is compared with the analysis of y alone. This fact is largely attributable to the reduction in the degrees of freedom of error from three to two. Even when the correlation is close, the loss of one degree of freedom in calculating the regression coefficient, is almost certain, with such limited data, to annul any advantage that might otherwise have been gained. The above example provides once again a useful illustration of the need of choosing the most appropriate method of statistical treatment. On the other hand, with an error variance based on a relatively large number of degrees of freedom, the use of one of these in estimating b does not greatly affect the calculated value of t, and the application of the regression function to the analysis will often be of undoubted advantage.

Short Methods of Computing the Analysis of Variance Using Regression.

The calculation of y−bx for each plot yield and the subsequent analysis is often laborious, particularly when b is a fraction taken to several places of decimals. Having worked out the sums of squares for y, x and xy, it is possible to reduce the amount of routine arithmetic by substituting the appropriate values in the equation given by Sanders.(4)

$$\text{S.S. } (y-bx) = \text{S.S.}y - 2b\ \text{S.P.}x.y + b^2\ \text{S.S.}x.$$

Substituting in Example IX for Error S.S. in each case

$$\left.\begin{array}{l}\text{S.S.}\\ \text{Error}\\ (y-bx)\end{array}\right\} \begin{array}{l}=15-2\times(-.65)\times(-13)+(-.65)^2\times 20.\\ =15-16.9+8.45\\ =6.55 \text{ (as originally calculated)}\end{array}$$

Similarly for Treatment S.S.,

$$\left.\begin{array}{l}\text{S.S.}\\ \text{Treat-}\\ \text{ment}\\ (y-bx)\end{array}\right\} \begin{array}{l}=50-2\times(-.65)\times(-30)+(-.65)^2\times 18\\ =18.60\end{array}$$

The value of the Total S.S. and Block S.S. of (y−bx) can be determined in the same way. In this example, b is an exact value, and the sums of squares as calculated by the two methods tally exactly. With actual yield data, b will normally be a decimal fraction, and the value of b and b^2 may have to be multiplied by relatively large numbers representing the sum of products (xy), and the sum of squares (x), respectively. In such cases in order to obtain an accurate analysis of variance of y−bx from the equation given, it may be necessary to calculate the value of b to anything from three to ten places of decimals according to the particular data concerned.

EXAMPLE X.

In most field experiments, the data recorded include such factors as grain and straw yield, number of plants per plot, green and dry weights, proportions of the different grades of produce, &c. If these records are analysed separately, it may frequently be found that the results are obscure and even contradictory. By calculating the analysis of covariance, it is possible to use the correlation between certain characters to arrive at a fuller understanding of the problems concerned and a more accurate interpretation of the data as a whole. The figures for the following small spacing experiment with cotton illustrate effectively the statistical procedure involved, and show how the more detailed analysis tends to augment the ultimate conclusions.

Table I.

Data for a Cotton Spacing Experiment.

Spacing.	Yield of Lint in Ounces per Plot. x						No. of Plants per Plot. y					
	Blocks.					Treatment Totals.	Blocks.					Treatment Totals.
	1	2	3	4	5		1	2	3	4	5	
A. (1′×2′)	15	11	12	8	6	52	12	14	14	15	17	72
B. (1′×3′)	5	6	10	9	4	34	10	11	8	8	12	49
C. (1′×4′)	4	7	6	3	4	24	7	5	5	8	7	32
	24	24	28	20	14	Grand Total. 110	29	30	27	31	36	Grand Total. 153

Table II.
Sums of Squares and Products.

x			y			xy		
Square of Plot Yields.	Square of Treatment Totals.	Square of Block Totals.	Square of Plant Numbers per Plot.	Square of Treatment Totals.	Square of Block Totals.	Plot Yield × Plant No.	Total Treatment Yield × Total Treatment Number.	Total Block Yield × Total Block Number.
225	..	..	144	..	..	180	..	..
25	2,704	576	100	5,184	841	150	3,744	696
16	..	..	49	..	..	28	..	..
121	1,156	576	196	2,401	900	154	1,666	720
36	..	..	121	..	..	66	..	..
49	576	784	25	1,024	729	35	768	756
144	..	..	196	..	..	168	..	..
100	..	400	64	..	961	80	..	620
36	..	..	25	..	..	30	..	..
64	..	196	225	..	1,296	120	..	504
81	..	..	64	..	..	72	..	..
9	..	..	64	..	..	24	..	..
36	..	..	289	..	..	102	..	..
16	..	..	144	..	..	48	..	..
16	..	..	49	..	..	28	..	..
974	4,436	2,532	1,755	8,609	4,727	1,185	6,178	3,296

Total S.S. $= 974 - 806.7 = 167.3$

Treatment S.S. $= \frac{4436}{5} - 806.7 = 80.5$

Block S.S. $= \frac{2532}{3} - 806.7 = 37.3$

Error S.S. $= 49.5$

Total S.S. $= 1755 - 1560.6 = 194.4$

Treatment S.S. $= \frac{8609}{5} - 1560.6 = 161.2$

Block S.S. $= \frac{4727}{3} - 1560.6 = 15.1$

Error S.S. $= 18.1$

Total S.P. $= 1185 - 1122 = +63$

Treatment S.P. $= \frac{6178}{5} - 1122 = +113.6$

Block S.P. $= \frac{3296}{3} - 1122 = -23.3$

Error S.P $= -27.3$

Table III.
Analysis of Variance and Covariance.

Due to	Degrees of Freedom.	Plot Yields. x		Plant Numbers. y		xy		Correlation Coefficient r
		Sum of Squares.	Variance.	Sum of Squares.	Variance.	Sum of Products.	Covariance	
Total ..	14	167.3	..	194.4	..	+ 63	..	+.349
Treatment	2	80.5	40.2	161.2	80.6	+113.6	+56.8	+.997
Block ..	4	37.3	9.3	15.1	3.8	− 23.3	− 5.8	−.982
Error ..	8	49.5	6.2	18.1	2.3	− 27.3	− 3.4	−.912

The treatment variance of x is significantly greater than the error variance as determined by the five per cent. value of z. A difference between treatment totals for yields of lint greater than 18.15 ounces is significant, showing that spacing A is better than C, but giving inconclusive results in the comparison of A with B, and B with C. The analysis of y shows that the difference between the plant numbers per plot for the three spacings A, B and C are real ones. This is to be expected in a spacing experiment in which the population per plot is fairly complete.

The correlation coefficients shown in the final column of the table are interesting. For the whole data, irrespective of block and treatment arrangement, the value of r is only +.349. If the analysis of covariance had not been carried out, this small value of r might have led to the assumption that there was no very marked association between the number of plants and the yield. When, however, the correlation is calculated for each particular factor in the analysis, it is at once apparent that the treatment yields are intimately linked with the number of plants. The high negative correlation for blocks is presumably fortuitous; the difference in the number of plants per block is relatively small, and the negative correlation merely shows that in this experiment, the blocks which have the fewest number of plants happen, by chance, to be the most fertile ones; and *vice versa*. The coefficient for error is really a partial correlation which means here that, in its calculation, the block and treatment factors have been eliminated.

The probability of significance of a simple correlation coefficient can be determined from the Table of t. The calculated value of t can be obtained from the equation

$$t = \frac{r \times \sqrt{n-2}}{\sqrt{1-r^2}}$$

where n represents the number of pairs of readings from which the correlation is determined.

From the table showing the analysis of covariance, the value of n—2 for any component—treatment, block, &c.,—will be equivalent to the degrees of freedom less unity.

From Table III, the calculated value of t for treatment correlation $= \dfrac{+.997 \times \sqrt{1}}{\sqrt{1-.997^2}}$

$= 12.85$

Reference to the table of t for a value of n = 1 shows that the probability that r is significant is greater than 20 : 1.

A quicker way of arriving at the same conclusion, would be to refer to Fisher's Table VA in which the value of the correlation coefficient for different levels of significance is shown. For n—2=1, the readings from this Table for a probability of .05=.996917 showing that the value of r of .997 is just significant on a 20 : 1 chance basis.

The Regression, $b_{x.y}$, *i.e.* of plot yield corrected for number of Plants $= \dfrac{\text{Error Covariance}}{\text{Error Variance of y}}$

$= \dfrac{-27.3}{18.1}$

$= -1.50828$

This regression value has been used to calculate the analysis of x—by, by substituting the appropriate values in Sanders equation,

$$\text{S.S. } (x-by) = \text{S.S.}x - 2b.\ \text{S.P. } xy + b^2\ \text{S.S.}y.$$

The use of Chambers seven figure logarithms made it possible to compute Table IV both accurately and quickly.

Table IV.

Analysis of x — by.

Due to	Sums of Squares.	Degrees of Freedom.	Variance.
Total ..	799.6	13 *	
Treatment	789.9	2	394.9
Block ..	1.4	4	.3
Error	8.3	7	1.2

The treatment variance is obviously significant when compared with the error variance. From Table I, the treatment totals for (x—by) are as follows :—

Treatment A $(1' \times 2') = 52 - (-1.508 \times 72) = 160.6$

" B $(1' \times 3') = 34 + 1.508 \times 49 = 107.9$

" C $(1' \times 4') = 24 + 1.508 \times 32 = 72.3$

A difference between such totals greater than $\sqrt{1.2 \times 5 \times 2} \times 2.365 = 8.19$ is significant. This proves that the closer the spacing the better the yield within the limits of $1' \times 2'$ to $1' \times 4'$. The use of the regression of plot yield on plant number has given a much more conclusive result than the direct analysis of plot yields alone. It might be argued that in a spacing experiment the elimination of the effects of the differences in population between plots is not desirable in assessing the treatment values. On the contrary the regression analysis provides additional information. It shows that even when the population differences are taken into account

* One degree of freedom has been used in the calculation of $b_{x.y}$.

in summing up the results, the close spacing still remains the one which gives the greatest yield. This would apparently demonstrate that with close spacing, not only are the plot yields higher, but the individual plants also grow better and produce more heavily.

In conclusion, the writer freely acknowledges that the gist of the subject matter in the preceding pages has been culled from various books and pamphlets on experimental statistics. The theorems expounded are all old ones, and this article is merely an attempt to present these in simple non-technical language which it is hoped will be comprehensible to the novice in statistical methods. At the same time it is advisable to point out that a rule-of-thumb application of such theorems to experimental data, without a reasonable understanding of the fundamental principles, is liable to lead to non-valid deductions and false conclusions. It is suggested therefore that this note should be used as an introduction to the more technical literature on any of the problems discussed, and not as a means of avoiding a fuller study of the subject, which alone will ensure an accurate interpretation of experimental results by applied statistics.

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REVIEW.

A TEXT-BOOK OF WEST AFRICAN AGRICULTURE, SOILS AND CROPS.

By F. R. Irvine, D.Sc., F.L.S. *Oxford University Press*, London: *Humphrey Milford*, 1934. 7*s*. 6*d*. 348 pp., 32 diagrams, 32 plates.

Dr. Irvine occupies the position of Chief Science Master at Achimota College in the Gold Coast, and it may be surmised that Agricultural Science finds a place in the College curriculum. Like most people who are engaged in teaching this subject in the Tropics, he has felt the need of some kind of text-book with which to work, and has accordingly produced this admirable book, which he hopes will be found useful for Secondary Schools, Training Schools and similar institutions. He disarms criticism by admitting that the book is very incomplete—the important subject of Livestock is for instance completely omitted, and that it has been produced in its present form, because no literature of this kind, suitable to Africans, exists.

In writing a text-book of agriculture the author may either describe the methods adopted by the local farmers in the area of which he is writing, or he may discuss improvements that can be suggested. Neither of these aspects will by itself suffice when treating of indigenous Tropical Agriculture, for one is dealing with a very wide variety of conditions and with a backward but rather rapidly changing system of agriculture. It is necessary therefore to compromise, and in the present volume Dr. Irvine appears to have done this successfully. There are for instance good straightforward accounts of the native cultivation of guinea corn and yams whilst at the same time, throughout the book, advice and recommendations on all subjects will be found.

In dealing with the production of indigenous food materials according to indigenous methods the distinction between Agriculture and Horticulture is not easy to draw, but this book, which peliberately omits all mention of the economic side of farming, has perhaps rather a bias to what may be called the 'school garden' point of view, and such criticism as follows, is from the agricultural aspect. It is hardly accurate to state, for instance, (page 67), that the practice of dry cultivation has revolutionised agriculture in dry regions of the world in the last 25 years or so. Centuries before that, the dry farmers of South India were successfully growing crops on a rainfall of 25 inches, with the use of drills and simple but efficient intercultivation implements. Again, the treatment of the African hoe is hardly commensurate with the importance of this universal tool. It is stated that the African prefers his own hoe to the European-made hoe, but no reason is vouchsafed for this, although later on we are told that the imported cutlass is being used increasingly. It is possible that the question of sharpening the harder steel of the imported blade is the difficulty. And why (p. 73) is it quite wrong to use a cutlass as a cultural implement, for surely the poverty of the African peasant suggests one multi-purpose implement rather than a number of specialised ones? The description of the spade is inadequate, and does not emphasise the fact that the African does most of his work by pulling and not pushing, and that the use of the spade and shovel does not therefore come naturally to him. A harrow (p. 78) is not necessarily made completely of iron; a most effective implement can be constructed of a wooden frame pinned together with the iron tynes.

These however are minor points which do not detract from the great value of this book, which is admirably suited for its main purpose—namely "to stimulate an interest in agriculture". A special word of commendation must be said of the plant sketches of Miss Deakin, while the plates add a great deal to the interest of the volume. A few minor misprints will no doubt be corrected in a subsequent edition, Styzolobium should be Stizolobium, and both Calopogonium and Calapogonium are used.

R. C. W.

OBSERVATIONS ON THE STORAGE OF VARIOUS FRUITS AND VEGETABLES.—(*Concluded.*)

II.—Papaws, Pineapples, Granadillas, Grapefruit and Oranges.

By C. W. Wardlaw, E. R. Leonard and R. E. D. Baker.
(*Imperial College of Tropical Agriculture.*)

PAPAWS.

The production, refrigerated storage and overseas transport of this fruit are attended with serious difficulties. In Trinidad, as elsewhere, the production of a standard variety or varieties suitable for export will require careful attention before questions pertaining to refrigerated storage can be tackled on an adequate scale.

In general, fruits for export should preferably be of smallish or intermediate size, and of a shape suitable for packing side by side in a standard crate. They should possess a reasonably tough skin to minimise the effects of bruising and should also show some degree of resistance to the normal storage pathogens. Lastly, apart from the obvious questions of colour, flavour and thickness of flesh, their constitution should be such as to ensure good keeping quality. Experience with Trinidad fruit indicates that in all of these matters great variability is the rule.

In working towards an export trade, the first half of the problem, namely the production of suitable standard varieties, clearly falls within the sphere of the plant-breeder and horticulturist. The difficulties attendant on the field aspect cannot be over-emphasised. The outstanding problem is undoubtedly the selection and perpetuation of good types from a plant which is notoriously variable. In addition, not only is investigation into cultural methods required to maintain the standard of production during the dry season, but there is the further problem of controlling the destructive and now widely distributed mosaic disease.

Need for Controlling Wastage.

In earlier investigations using local varieties, wastage during storage was very great indeed. As most of this could be attributed to latent or dormant infections established at some earlier period or to the germination and growth of fungal spores lodged on fruits in the field, in the current series of experiments periodic spraying of fruits prior to reaping was accordingly undertaken to determine if such procedure led to a noticeable reduction in the incidence of storage rots.

Although spraying operations using Bordeaux mixture, two per cent. Sulphemulsol, and standard Sulsol *plus* Bouisol respectively, were carried out at weekly intervals, no definite expression of opinion can be given as to the efficacy of such treatments from the present season's experience. It could not be asserted that treated fruits have shown less infection and wastage in storage than untreated fruits. It should be mentioned, however, that the quantities of fruit available for observation were seriously decreased by the destruction of plants by mosaic disease. With the onset of the dry season under the existing conditions of cultivation the failure of the younger fruits to mature also curtailed supplies. The effectiveness of two per cent. Sulphemulsol and standard Sulsol *plus* Bouisol sprays in cleaning up fruits was noteworthy, but the extent to which they afford actual protection against fungal pathogens still remains to be determined.

Attempts to eliminate storage pathogens by steeping fruits for ten minutes in 1 in 1,000 potassium permanganate and in three per cent. formalin respectively were also unsuccessful, indicating that dormant infections, in which the fungus is established in a resting condition within the epidermal or sub-epidermal tissues, cannot be controlled by such methods.

These findings, though in themselves negative or inconclusive, show that if spraying operations are to be attended with significant results they must be undertaken periodically from the time the young fruits are set. As fruits for export should be yellowing at the time of reaping (*see* below), the need for affording protection against birds and other predators should receive adequate consideration.

Storage Trials.

Fruits, reaped by cutting with a sharp knife, were stored at three stages of development, namely, (1) full-grown but green, (2) with first traces of yellowing, (3) more or less completely yellow but still quite firm. Comparable lots were held for periods of 15 and 20 days and at temperatures of 45°F. and 50°F. Small lots were also ripened at tropical temperatures (80°F. approx.).

From the data obtained only general conclusions need be stated at this stage of the investigation.

1. As a rule, wastage was serious at both temperatures, but was noticeably worse in fruit held at 50°F. It was evident that some types of papaw possess greater resistance to storage or late maturity pathogens than others.

2. In the course of 20 days at 45°F. and 50°F. respectively, apart from the onset of wastage, there was no evidence, as judged by external criteria, that maturation had advanced significantly in any of the three classes of fruit. Even the yellow fruits were still quite firm, and apparently unaltered from the time of reaping.

3. Green fruits, on transference to the ripening room at 70°F. failed to ripen and were soon overrun by numerous fungi or partly shrivelled before any trace of colour appeared. It is evident that fruit reaped at this stage of maturity is quite unsuitable for export. Slightly coloured fruits were little better as regards external appearance, but became soft and were quite palatable. The almost fully coloured fruits, on the other hand,

were normal in behaviour. In some types, in which storage pathogens had become established, degeneration at the higher temperature was rapid and within two days the fruits were unsightly and unfit for use. A few of the yellow fruits, however, undoubtedly possessed a better keeping quality and were still in good condition after three to four or five days at 70°F. In our opinion, provisionally stated, fruit for export should be reaped when yellow but quite firm, and held at 45°F.

4. There was also definite evidence that some varieties on transference to the ripening room or if held at tropical temperatures ripen more rapidly than others.

5. In attempts to secure a partial ripening of green or slightly yellow fruits by holding them for a few days at tropical temperatures prior to cold storage, the subsequent onset of wastage was excessive.

These results, while neither conclusive nor satisfactory in themselves, indicate that the overseas transport and distribution of the papaw is by no means impossible provided suitable types can be selected. It is also evident that fruits should be well coloured, but still firm at the time of reaping. As these remain practically unchanged during 20 days storage at 45°F., they should, if carefully packed, be available for retailing on distant markets. In handling a delicate fruit like the papaw, it would be understood, of course, that adequate care, and possibly some refrigeration, should be given during distribution. The handling of green or slightly coloured fruits at a higher storage temperature, say 55° to 60°F. to permit of partial ripening during the voyage period, is precluded by the onset of fungal wastage at temperatures above 50°F.

Wastage.

Many fungi, both in a primary and secondary capacity, are responsible for the production of spots, soft-rots and the ultimate decline of papaws in storage.

Gloeosporium sp. This is perhaps the commonest storage pathogen. At 45°F. and 50°F. it remains suppressed for approximately 15 days, but thereafter small circular sunken blemishes begin to appear. As these expand they become covered with pinkish and later dark or black acervuli, or they may be overgrown and obliterated by secondary fungi. The conidia of *Gloeosporium* as observed on the papaw in Trinidad are typically elongated, with parallel sides and rounded ends, at first pink *en masse*, becoming dark coloured on drying; some of the conidia may be slightly concave and pointed at one end; measurements 16-20 × 4-6 μ, no setae observed. Elsewhere *Gloeosporium cingulatum* Atk. and *G. papayae* Henn. and *Colletotrichum gloeosporioides* have been recorded on the papaw.

Phomopsis papayae Frag. and Cif. causes large, spreading blemishes with a black, corrugated pycnidial crust. This fungus is of occasional occurrence only.

Fusarium dimerum Penz. *pusillum* Wr. Some fruits on removal to the ripening room developed a large number of small, slightly sunken spots distributed generally over the surface. The spots were covered with a powdery surface mycelium bearing the numerous non-septate and one-septate conidia of the above species. Other species of *Fusarium* were associated with wound infection and spreading blemishes.

In a secondary capacity, *Penicillium glaucum* Link. and species of *Cladosporium*, *Rhizopus*, *Fusarium*, *Saccharomyces*, *Oidium*, *Fusidium*, *Helminthosporium* and other fungi were conspicuous.

PINEAPPLES.

According to the Conference Report "there does not appear to be any immediate possibility of reviving the former export industry in fresh pineapples from the West Indies, but market demands would appear to warrant trial shipments to the United Kingdom and Canada. . ."

Although individual crates of fruit sent overseas in ships' provision rooms have reached their destination in good condition, experimental investigations have shown that this fruit, being subject to an internal physiological breakdown, cannot endure low temperatures. In Porto Rican fruit held for six days at 53°F. and 40°F., maturity changes both in green and ripe fruit were considerably retarded without interfering with the subsequent ripening at a higher temperature (1). From the literature available, it may be anticipated that in dealing with the refrigerated storage of the pineapple, variety, time and temperature factors will prove important.

At the Low Temperature Station, small lots of green or slightly ripened pineapples of the Sugar Loaf variety were held at 60°F. and 50°F.—temperatures higher than those employed elsewhere being selected to avoid possible chill effects. The cut stem-ends were sealed with latex solution. After eleven days some of the fruits had become quite ripe at both temperatures. Fruit held at 60°F. was very juicy; physiological core-rot and stem-rotting were absent. While the flavour of the ripe fruit was excellent, there was evidence of uneven ripening—other than that normally found on proceeding from the apex to the base—and instead of a full yellow colour being produced, a dark or dingy yellow was the rule. Fruit held at 50°F. was also of good flavour, though noticeably more acid; there was no evidence of abnormal internal disturbance, but again the colour at maturity was dark green instead of yellow. The flesh was noticeably less yellow than in fruit held at 60°F.

After 15 days at 60°F. fruits had become overripe, with irregular marginal areas where senescence was accompanied by the inroads of fungi (species of *Fusarium* and *Penicillium*) and the production of an alcoholic odour. Some

(1) Porto Rico Station Report, 1923.

fruits showed a slight development of a physiological darkening in the core. Fruits held at 50°F. had become ripe, were of good flavour, but the colour at maturity was again an abnormal dark green.

These brief observations indicate that pineapples, grown under Trinidad conditions, fall into line with those produced elsewhere in that their refrigerated transport (extending over at least 15 days with a subsequent distribution period of, say, ten days at a higher temperature) will require careful investigation. Arrangements are being made to continue these studies.

GRANADILLAS.

Fruits of the granadilla (*Passiflora macrocarpa*), picked yellow, turning and green, were stored in small quantities at 50°F. for 17 days, then transferred to the ripening room at 70°F.

After seven days at 50°F. the yellow fruits, which were already almost ripe on reaping, had become over-ripe, soft and leaking. Green fruits showed little change during the entire period in cold storage, but turning fruits showed a slight increase in colour. In the course of seven days at 70°F., turning fruits became quite ripe and soft and green fruits became slightly coloured, soft and ready for use.

In a second experiment, green and turning fruits were held at 45°F. for 15 days and subsequently ripened at 70°F. in the course of seven to ten days.

If required for export, this fruit should not prove difficult to handle. Although prized locally for the preparation of ices and drinks—the pulp has a pleasant sub-acid flavour—the cost of crating and freight for such a large fruit (some are nine inches long) would seriously militate against its economic disposal on distant markets, even supposing a small demand could be created.

Wastage.

Except for small spots caused by an undetermined fungus (? *Phleospora* or *Septoria* sp.) already present on fruits on the vines, no fungal wastage was incurred until a late stage in the ripening rooms when various soft-rotting organisms developed on leaking and over-ripe fruits.

GRAPEFRUIT.

With the rapid expansion of the grapefruit industry in Trinidad and other West Indian Islands, it has been considered expedient to undertake storage trials with different varieties under controlled conditions of temperature and humidity.

Depreciation in consignments is referable to (1) the onset of fungal wastage, and (2) decrease in moisture content. On both of these aspects precise information regarding fruit grown under Trinidad conditions has not hitherto been available. In the storage experiments to be described here, fruits were held at temperatures of 45°F. and 50°F. respectively. In the circumstances of the investigation no attempt was made to study the question of keeping quality over a wider temperature range. The limits of chilling, the effect of variety, season, gummosis infection and environment are being held over for investigation later.

Loss of Weight in Freshly-Reaped Fruit.

Three varieties, namely, Marsh, Duncan and Pernambuco obtained from River Estate (March, 1934) were taken into storage immediately after reaping and held at 45°F. (relative humidity 85 per cent.) and 50°F. (relative humidity 80 per cent.) respectively. The fruits were fully exposed to the cold air blast and the percentage loss in weight determined at intervals over a period of 51 days, Table VI.

Table VI.

LOSS OF WEIGHT IN FRESHLY-PICKED GRAPEFRUIT AT 45°F. AND 50°F. RESPECTIVELY.

Variety.	Av. wt. of one Fruit.	Temperature.	Percentage Loss in Weight after				
			10 days	19 days	30 days	40 days	51 days
Marsh	491 gms	45°F.	0.9	1.0	2.8	3.8	4.8
	485 ,,	50°F.	1.5	2.6	4.8	5.3	6.9*
Duncan	388.5 ,,	45°F.	1.3	2.0	3.3	4.3	5.1
	389 ,,	50°F.	1.3	2.2	3.1	4.2	5.1
Pernambuco	499 ,,	45°F.	1.5	2.7	4.1	5.4	6.7
	494 ,,	50°F.	1.8	3.3	4.4	5.7	7.1

Effect of Standard Commercial Treatments.

With the assistance of Mr. C. B. Anderson of the local Co-operative Citrus Growers Association, observations were made on consignments of fruits which had been subjected to a number of the different commercial treatments now in use. The object was to determine the influence of such treatments on keeping quality and wastage. Samples of 100 fruits, treated as follows, were held at 45°F. and 50°F. respectively :

Treatments.

1. Washed and waxed.
2. Washed only.
3. Coloured and washed.
4. Borax solution, coloured and washed.
5. Coloured, washed and waxed.

Notes: Washing refers to the normal machine washing; waxing, a process designed to curtail desiccation, consists in running fruits through a proprietary solution in which wax in a paraffin base is emulsified in water; colouring refers to the ethylene treatment for colouring fruits; fruits

* Rusty sunken spots covering part of the surface of one fruit.

were dipped in borax solution as a fungicidal treatment. In these trials, culled samples were chosen in preference to standard samples, so that depreciation due to desiccation and fungal activity would be more marked. A consignment of freshly reaped fruit was kept as a control. The percentage losses in weight in the several samples is shown in Table VII, and fungal wastage in Table VIII. It should be remarked that at the commencement of the experiment the turgidity of the treated fruits was already noticeably decreased.

Table VII.

LOSS OF WEIGHT IN MARSH GRAPE-FRUIT (CULLS) AT 45°F. AND 50°F. AFTER DIFFERENT TREATMENTS.

Treatment.	Sample.	Av. Wt. of one Fruit.	Temperature.	Percentage Loss in Weight after				Mean loss after 80 days.
				30 days.	45 days.	60 days.	80 days.	
		gms.						
1. Washed and Waxed ..	A	505	45°F.	3.7	5.4	7.1	9.1	8.9 per cent.
	B	513		3.8	5.5	7.3	9.4	
	C1	665		3.1	4.4	5.7	7.4	
	C2	657.5		4.0	5.7	7.5	9.6	
2. Washed only	A	501		3.8	5.5	7.1	9.3	8.9 per cent.
	B	530		3.2	4.6	5.9	7.7	
	C1	658.5		3.8	5.6	7.4	9.5	
	C2	671		3.6	5.2	7.0	9.1	
3. Coloured and Washed ..	A	615		3.2	4.7	6.3	8.0	7.8 per cent.
	B	571		3.6	5.2	6.8	8.7	
	C1	753		2.9	4.2	5.6	7.2	
	C2	739		3.0	4.3	5.6	7.2	
4. Borax, Coloured and Washed	A	593		3.9	5.7	7.5	9.7	9.3 per cent.
	B	535.5		3.4	5.0	6.5	8.5	
	C1	655.5		4.0	6.0	7.9	10.4	
	C2	704.5		3.5	5.0	6.7	8.6	
5. Coloured, Washed and Waxed	A	527		3.5	5.2	6.8	8.8	7.6 per cent.
	B	503		3.2	4.6	6.0	7.7	
	C1	695		2.9	4.1	5.4	7.1	
	C2	772		2.6	3.8	5.1	6.6	
6. Control, freshly reaped fruit	A	473.5		4.9	—	—	—	
	B	541		4.1	—	—	—	
1. Washed and Waxed ..	A	518	50°F.	4.0	5.9	7.7	9.7	9.4 per cent.
	B	494		3.9	5.5	6.9	8.6	
	C	672		4.2	6.1	7.8	9.9	
2. Washed only	A	565		4.7	6.8	8.9	11.0	9.9 per cent.
	B	610.5		4.2	6.0	7.8	9.8	
	C	795		4.1	5.7	7.2	8.9	
3. Coloured and Washed ..	A	511		3.6	5.1	6.1	8.0	8.3 per cent.
	B	540.5		3.7	5.2	6.5	8.0	
	C	765		3.9	5.6	7.1	8.8	
4. Borax, Coloured and Washed	A	511		5.6	7.5	9.1	11.7	11.4 per cent.
	B	506		6.0	8.5	11.1	13.5	
	C	659		3.8	5.5	7.1	8.9	
5. Coloured, Washed and Waxed	A	565		4.1	5.9	7.5	9.2	9.4 per cent.
	B	502		4.0	5.7	7.2	8.9	
	C	783.5		4.4	6.2	8.1	10.0	
6. Control, freshly reaped fruit	A	478		5.1	7.2	—	—	
	B	511		4.7	6.6	9.5	—	

Fungal Wastage.

Anthracnose Soft-Rot (*Colletotrichum gloeosporioides* Penz) causes a soft-rot on over-ripe or fallen fruit. The soft-rot spreads slowly, but in the course of 30 days may form a blemish 5-6 cms. in diameter, the rind being turned a brownish colour. In some instances, *e.g.* in stylar infection, the disease advances inwards along the placentae producing a salmon to brown discolouration. Over the diseased surface, the acervuli of *C. gloeosporioides* break through the epidermis in concentric rings and in due course the pale or yellowish conidial masses appear. The conidia are elongated with parallel sides or very slightly ovoid, typically rounded at one end and slightly pointed at the other: measurements 18-21 × 4-5μ; setae septate and smoky, measuring 80-100 μ.

Blue Mould (*Penicillium italicum* Wehm.).—This has been the commonest cause of wastage in stored grapefruit. In the course of 20 to 30 days fruits may become more or less completely covered by the characteristic pale-medium blue mould of *P. italicum*, the pulp being completely rotted. Infection by this organism is usually associated with injuries. Although sometimes referred to as "blue-contact mould," spread by contact in heaped-up, unwrapped fruits, it was not particularly observed during these storage trials (with relative humidities of 80 to 85 per cent.). It is open to doubt whether the use of borax solution applied under commercial conditions at the local packing shed has afforded the desired measure of control over this fungus. Careful handling at all stages is the best means of avoiding this type of wastage.

Green Mould (*Penicillium digitatum* (Fr.) Sacc.), though considerably less in evidence in these trials than *P. italicum*, has occasioned some wastage, sometimes in conjunction with the latter organism. The conditions for attack are similar to those for the common blue mould.

Phomopsis citri Fawcett.—This fungus is responsible for the production of pliable leathery brown rots distributed over the fruit surface, but more often localised at the stem-end. Internally the fruit is deeply rotted and slightly to moderately discoloured, especially along the central junction of the segments. In the specimens examined, both the A and B spores were obtained from pycnidia on the surface of infected fruits.

Table VIII.

FUNGAL WASTAGE IN MARSH GRAPEFRUIT (CULLS) AT 45°F. AND 50°F. AFTER DIFFERENT TREATMENTS.

Treatment.	Temp. Deg. F.	Percentage Wastage after			
		30 days	45 days	60 days	80 days
1. Washed and Waxed	45°F.	1.0	3.0	3.0	3.0
	50°F.	0	0	0	0
2. Washed only	45°F.	0	1.0	1.0	1.0
	50°F.	0	1.0	1.0	2.0
3. Coloured and Washed	45°F.	0	0	0	0
	50°F.	1.0	1.0	1.0	4.0
4. Borax, Coloured and Washed	45°F.	3.0	5.0	6.0	6.0
	50°F.	5.0	8.0	11.0	14.0
5. Coloured, Washed and Waxed	45°F.	1.0	1.0	1.0	1.0
	50°F.	1.0	4.0	4.0	5.0

Table IX.

PERCENTAGE LOSS IN WEIGHT IN DIFFERENT ORANGE VARIETIES.

Variety.	Av. Wt. of one Fruit.	Temperature.	Percentage Loss in Weight after					
			10 days.	19 days.	30 days.	40 days.	51 days.	70 days.
	gms.							
King: green	289.5	45°F.	2.2	3.7	5.5	7.2	8.9	11.6
King: turning	321.0		2.5	4.5	6.2	8.5	10.4	13.4
King: ripe	304.5		2.2	3.9	5.8	7.8	9.5	12.5
Valencia	249.5		1.7	3.7	4.6	5.6	6.9	9.2
Jaffa	339.5		2.1	2.7	4.8	6.3	7.8	10.3
Pineapple	264.0		2.2	3.6	5.6	6.7	8.2	10.8
Navel	303.5		2.4	3.8	5.6	7.5	9.4	12.5
Lamb's Summer	193.0		2.8	4.4	5.8	7.6	9.2	12.1
King: green	293.0	50°F.	2.4	4.1	6.2	8.3	10.2	13.1
King: turning ..	319.0		3.2	5.1	7.6	10.0	12.4	15.9
King: ripe	304.0		2.7	4.4	6.6	8.9	11.2	14.4
Valencia	256.0		2.0	3.5	5.1	6.8	8.6	11.2
Jaffa	336.0		2.4	4.2	6.1	8.1	10.1	12.8
Pineapple	262.0		2.1	3.6	5.2	7.0	8.9	11.3
Navel	306.0		2.4	4.2	6.1	8.1	10.0	12.8
Lamb's Summer	191.0		3.3	5.2	7.4	9.7	12.0	15.1

STORAGE OF THE KING ORANGE AND OTHER VARIETIES.

In experiments conducted in 1933 it was shown that the King Orange or Giant Mandarin (a variety of *Citrus nobilis*) possesses very good keeping qualities (1), medium and large sized fruits having been held at 45°F. for 60 days with negligible wastage.

During the current investigations King oranges from three localities and a collection of orange varieties from River Estate, including Valencia, Navel, Pineapple, Lamb's Summer, Jaffa, were held at 45°F. and 50°F. fully exposed to the cold air blast and losses in weight due to dehydration determined at intervals. Other wrapped samples, packed in 20-lb. crates were duly examined for keeping quality and fungal wastage.

Table IX shows the percentage loss in weight for the several varieties, the observations for the King Orange referring to fruit picked at three stages of maturity, namely, green, turning and ripe.

After 50 days in cold storage, the several varieties of orange were still for the greater part in good condition. In the Lamb's Summer variety, a slight desiccation and darkening round the stem-end had made its appearance in most of the fruits. Fungal wastage in all varieties was negligible.

In the King Orange consignments, originally stored green, turning and ripe, some differences were noted at the two temperatures. At 50°F. both green and turning fruits had ripened to a more or less complete yellow skin colour. Fruits picked when quite ripe, though still very attractive externally, had lost all traces of acidity and their flavour had accordingly depreciated, the juice being insipid, sweet and watery. Fruit at this stage of maturity should not be stored unless speedy consumption is assured. Even at 45°F. this class of fruit had lost its flavour. At this temperature, an increase in maturation had also taken place, green fruits having become greenish yellow and turning fruits almost full yellow.

To the Trinidad Department of Agriculture and to the College Departments of Agriculture and Mycology, the writers are much indebted for supplies of fruit.

THE AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE—PUSA.

THE recent earthquake which, in January last, wrought such destruction and caused heavy loss of life in Bihar and Nepal has very severely affected the Pusa Institute, the headquarters of the Imperial Department of Agriculture in India, and from the accounts which have reached us from various sources, it seems likely that the magnificent building which was completed in 1907, has been damaged beyond possibility of repair. Reports have recently appeared in the papers of further shocks in the neighbourhood of Mozuffarpore, which is only a few miles away, and these will probably have completed the damage.

The experience was frightful. Preceded by a tremendous noise, "like the braking of countless trains", a succession of small shocks was followed by three violent heaves, in which the earth moved sharply up and down a vertical distance of two feet. It may be presumed that it was this severe movement that brought down the wings of the Institute and was responsible for a crack through the centre of the building. Its effect on the apparatus and chemicals in the laboratories must have been devastating.

Meanwhile, through fissures in the ground, hot water and mud and sand were being ejected in quantities so great that one correspondent stated it was the most terrifying feature of the quake, "as it was evident that if the sand and water came up for a sufficient time, we must all be buried".

We are not without experience of earthquakes in the West Indies, but fortunately not on this scale. We tender our sympathy to the Pusa staff who at one stroke have lost their College, their land, and the fruits of their labours.

MAIZE IN CHINA.

IN the annual report of the Librarian of Congress for 1933 (Washington, D.C.) Dr. Walter T. Swingle of the United States Department of Agriculture comments in the report of the Division of Orientalia on certain acquisitions in Chinese literature which refer to maize and other natural products. What would appear to be the earliest reference to maize in China is found in a work entitled *Liu-ch'ing jih-cha* by T'ien I-hêng who was born in 1524. The title of the work literally translated is "Preserved Green Daily (notation) Tablets", it being so called from the fact that it consisted of notes which had been scratched on the leaves of a bamboo grove by the author in his daily walks and meditations. Maize is here described in detail. It is called *yü mai* (Imperial grain) and is said to have come in through *Hsi fan*, literally the western barbarian region, a term which was often used to mean Tibet. Its old name is said to have been *fan mai*, literally barbarian wheat. It is thus clear that maize had been cultivated for some time before the publication of this work in 1573. Three further references to maize occur in Chinese literature between 1573 and 1590, of which at least one was copied from T'ien I-hêng's account. Wang Shih-mou in 1587 gives a different name for it and says it was boiled and eaten. These accounts make it clear that within eighty years of the discovery of America by Columbus, maize had reached China. As the records are unanimous that it came from the west, Dr. Swingle suggests that it was not introduced by the Portuguese through Goa as is usually thought, but by the Arabs, who carried it from Spain to Mecca, whence Moslem travellers would have brought it to China through Central Asia. Tobacco, on the other hand, it would appear from a reference in another work, was not planted in China until the third decade of the seventeenth century.—(*Nature*, No. 3359, Vol. CXXXIII, 1934, p. 420.)

(1) *Trop. Agriculture* X, 7, p. 191, 1933.

GUMMOSIS OF CITRUS IN TRINIDAD.

I. 'Marsh' Grapefruit on Sour Orange Stock.

By R. E. D. Baker.
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I.—Introduction.

Gummosis disease of Citrus has probably been present in Trinidad for a considerable time, but has only become of any economic importance since the development of the grapefruit industry during the past twelve years. Grapefruit (*Citrus paradisi Macf.*) is very susceptible to gummosis, and at the present time this is easily the most serious disease of the crop in Trinidad. Unless proper precautions are taken to avoid it, gummosis is capable of killing out whole fields of grapefruit trees during their first few years of bearing, thereby causing serious losses. In addition to this, fruit from diseased trees is not normal, but being of medium size and attractive appearance tends to be included in consignments for export. It is an open question whether such fruit will behave normally in cold storage—a problem which has been noted for investigation at the Low Temperature Station.

The object of the present paper is to put on record the results of a preliminary survey of gummosis disease on 'Marsh' grapefruit, the variety most commonly grown in Trinidad, and at the same time to make a few recommendations for its control. The symptoms of the disease are a copious exudation of gum from the trunk of the tree and subsequent death of the bark. Several fungi have been isolated including a Phytophthora species, but up to the present none of them has definitely been proved to be pathogenic. It is hoped that it will be possible in a further paper to report more fully on the disease.

II.—Field Observations.

During the dry season of 1934 a survey was made of the majority of the older grapefruit estates in Trinidad. The objects of this survey were, firstly, to see how serious gummosis was on the 'Marsh' grapefruit, and secondly to find out, if possible, how the disease was influenced by local conditions on the various estates visited. Statistical records were made on nine fields located in six estates in the Northern Range and in the centre of the island. Trees between the ages of 5 and 12 years were examined, and, where feasible, records were taken from at least a hundred trees in each field. The following notes were made on each tree :—

(*a*) the height of the bud union above ground level,
(*b*) the height of the lowest fork above ground level,
(*c*) whether the tree was affected by gummosis or healthy,
(*d*) if gummosis was present, whether it was on the sour orange stock, the grapefruit scion, or on both together,
(*e*) whether the tree was seriously or slightly attacked (*i.e.*, more or less than 50 per cent. ring-barked by the disease).

The data obtained in this way is summarised in the following table.

TABLE I.

Gummosis of 'Marsh' Grapefruit.

Field.	Age of tree (years).	Number of trees examined.	Mean height of bud union (inches).	Mean height of first fork (inches).	Percentage with gummosis on grapefruit scion.		Percentage with gummosis on sour orange stock.	
					Total.	Serious.	Total.	Serious.
A	5-6	125	4.17	16.0	63.0	40.0	17.0	**2.0**
B	7	98	4.44	10.6	78.0	49.0	18.0	**2.0**
C	6	100	4.56	18.6	52.0	35.0	15.0	**0.0**
D	5	135	5.13	18.2	36.0	20.0	8.0	**1.0**
E	8-12	632	5.20	17.8	28.5	13.0	14.0	**0.2**
F	8	155	5.98	14.5	59.0	27.0	13.0	**0.0**
G	8-10	50	**6.96**	22.5	**4.0**	**4.0**	**0.0**	**0.0**
H	5	100	**8.30**	23.8	**2.0**	**0.0**	**0.0**	**0.0**
I	5	150	**11.80**	29.4	**2.0**	**0.0**	**0.7**	**0.0**

Two points in this table are noteworthy: firstly, the obvious effect of the height of the bud union on the incidence of the disease; and secondly, the marked resistance to gummosis shown by the sour orange stock. In the six fields (A, B, C, D, E and F) where the mean height of the bud union above ground level was low—*i.e.*, between 4.17 and 5.98 inches—the percentage of diseased trees varied from 28.5 per cent. to 78 per cent. In the three fields (G, H and I) however, where the mean height of the bud union above ground level was higher—6.96, 8.30 and 11.80 inches—the number of diseased trees fell to four per cent., two per cent., and two per cent. respectively. These figures show clearly that high budding on resistant sour orange stock has a marked effect in reducing the incidence of gummosis.

Fig. 1.

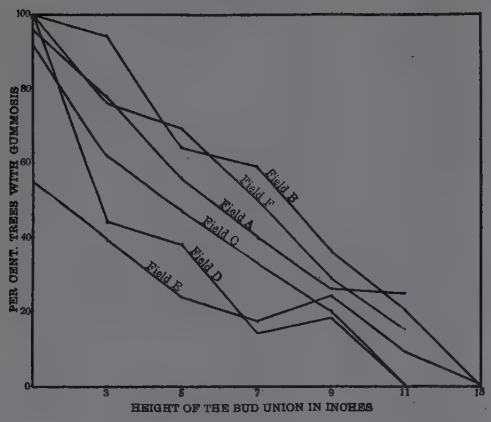


Fig. 2

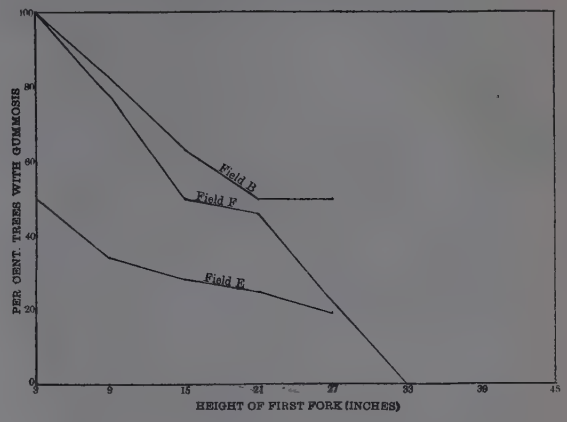
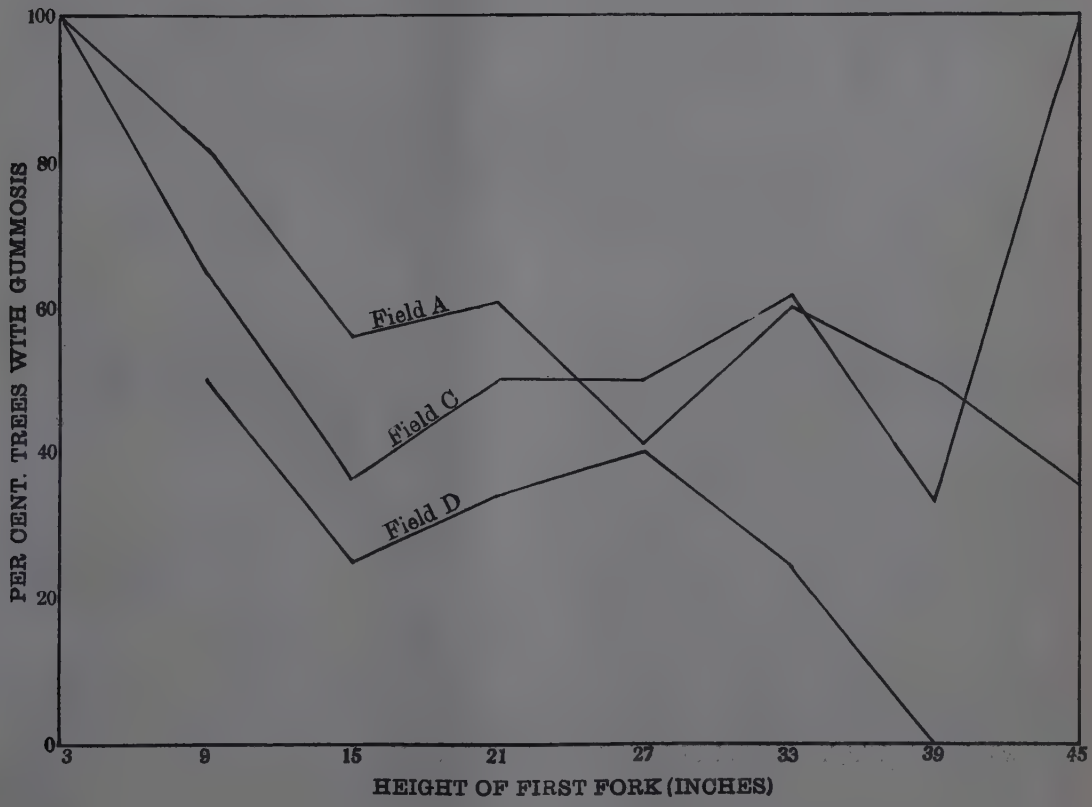


Fig. 3.



With regard to the resistance of the sour orange stock to gummosis, it can be seen from the above table that in no field was the stock seriously attacked in more than two per cent. of the trees examined—not even in cases where 40 per cent. and 49 per cent. were seriously attacked on the grapefruit scion. The figures obtained for total incidence on the sour orange stock in fields A, B, C, D, E and F seem unduly high at first sight, but this can be explained a follows. The disease attacks the tree as a rule just above the bud union, since this is the lowest point reached by the susceptible grapefruit scion. From there it spreads rapidly up the scion where most of the damage is done, but in some cases it also spreads slowly down into the highly resistant, though not completely immune sour orange stock. Generally speaking, the sour orange used as stocks for grapefruit in Trinidad showed a high degree of resistance to gummosis on all the estates visited. The important point is that on low-budded trees the disease nearly always starts on the scion.

The data was next analysed to find out in what way the percentage of diseased trees in any given field falls off as the height of the bud union above soil level increases. This is demonstrated in Fig. I. which shows that trees over five years old, with the bud union only one inch above ground level, are almost invariably attacked by gummosis but that the incidence of the disease falls off rapidly as the height of the bud union is increased. A critical height would appear to be reached at about 12 inches. On the better cultivated estates, with suitable topography, nearly all the trees with the bud union 12 inches above the ground are healthy, while on other estates 10 to 20 per cent. of the trees with the bud union at this height are diseased. It is obvious therefore that even on the best estates a *minimum* safe height for budding is between 12 and 18 inches, and that it would be sound practice, in the majority of cases, to bud the trees at 18 to 24 inches. Even when the standard of cultivation is high and the trees are round-weeded regularly, the height of the bud union cannot be less than 12 to 18 inches above soil level without running a serious risk of gummosis.

The effect of the height of forking of the tree on gummosis is not nearly so marked as that of the height of the bud union, but there is no doubt that it has some importance. Trees which fork low generally have their branches touching the ground all round; this will tend to raise the humidity about the trunk and probably increase the liability of the tree to attack by gummosis. On some estates (fields B, E and F) it was definitely shown that the incidence of the disease falls off as the height of forking above ground level is increased. (*See* Fig. II.) On other estates however it has no apparent effect, and the trees which forked high appeared to be just as seriously diseased as those which forked low. (*See* Fig. III). A further point worthy of mention is that water is liable to run down the underside of a branch and keep it moist for longer periods than the upper side of the same branch. When the branch was near the ground it was found that this region and also the inside of the fork of the tree frequently furnished a starting point for the disease.

In two or three cases gummosis was found several feet above ground on the undersides of branches. This type of attack, high up the tree, is fortunately of infrequent occurrence in Trinidad and has only been seen in very wet areas which are hardly suitable for the cultivation of grapefruit even under the best management. Trees attacked in this way were almost always seriously attacked lower down the trunk as well.

While these records were being taken additional notes were made on the effect of other factors—such as drainage, soil, planting methods, and the standard of cultivation—on the incidence of gummosis. It was not possible to do this statistically but certain generalisations can be made from the information obtained.

Drainage.—This is a matter of great importance. Trees in wet, low-lying fields where the water table is high (as in field B) are more seriously attacked than those in drier areas. Adequate drains should be provided in grapefruit fields, as a wet soil and the rank growth of weeds resulting from failure to attend to this point produce conditions favourable for a severe attack of gummosis.

Soil.—It is difficult to estimate the effect of different types of soil on gummosis. Grapefruit trees on a heavy wet soil are probably more seriously attacked than those on a well-drained sandy soil, but plenty of serious attacks have been seen on the latter type. It is improbable that differences in soil have any very important effect on gummosis in Trinidad.

Planting Methods.—There is obvious difficulty here of obtaining reliable information as to the influence of planting methods on disease incidence in trees which are five or more years old at the time of examination. Without a doubt the chief aim in planting should be to make the bud union as high as possible above ground level. The trees should be planted on mounds, never in holes, and adequate provision should be made for the tree to settle without the collar sinking below ground level. The worst field seen in the island field B, with 78 per cent. of the trees diseased, was one in which the trees had been planted in holes and had sunk so deep that in several cases even the bud union was buried below the ground.

Cultivation and Maintenance of Grapefruit trees.—This is undoubtedly a very important aspect. If gummosis is to be avoided in the future, more money will have to be spent on cutlassing and round-weeding than is at present the case. If grass and weeds are allowed to grow up round the trunks of the trees as far as the bud union, conditions will be damp enough at this point for gummosis to gain a hold. As a further means of reducing the humidity around the base of the tree it should be trimmed of all low branches as soon as the fruit has been picked. At the same time, a general 'cleaning up' of the trees to remove moss and epiphytes is also desirable.

III.—Discussion.

These investigations show that with regard to the avoidance of gummosis on grapefruit in Trinidad two very important points are: firstly, the production of suitable trees in the nursery, and secondly the proper care of those trees after they have been planted out in the field. As recommended by Briton-Jones (1) trees should be budded at a height of 18 inches on good sour orange stock; trees should never be budded below 12 inches, and in some cases it may be beneficial to go as high as two feet. Sour orange stock is highly resistant to gummosis in Trinidad, and it is hoped that it will be possible to compare its merits in this direction with those of the rough lemon and other stocks at a later date. When plants are transferred from the nursery to the field they should be planted on mounds, never in holes, in order to keep the bud union as high as possible above ground level. The trees should be round-weeded at regular intervals, and at no time should weeds and grass be allowed to grow up above the bud union; if this is not attended to, serious risk of gummosis is incurred. In round-weeding a tree which has been planted low, care must be taken to avoid forming a saucer-shaped hollow around the base by hoeing away too much soil. A hollow of this nature will hold water in the wet season and render it very liable to gummosis. The young trees, which should have been headed high (at least 3 ft. 6 ins. or 4 ft.) in the nursery, should be carefully pruned so as to remove all down-growing and low branches. This can be done easily with pruning scissors in the early stages thus saving the expense of a heavy trimming when the trees are older. The object of this trimming is to admit air and light to the trunk of the tree, and by so doing reduce the chances of gummosis attack. If grapefruit is raised and cared for in this way there should be little to fear from the disease.

These recommendations are, however, of little value to estate owners who have large areas planted in grapefruit already seriously attacked by gummosis. Many of these trees are low budded and low planted, branching only a few inches above ground level. In some cases the bud union has actually sunk below ground level and the fork is only just above it. These conditions, combined with a heavy growth of weeds and lack of drainage, are ideal for gummosis attack and several estates have already lost many trees from these causes.

It is not suggested that it is possible to control gummosis under these conditions. A grapefruit field is expensive to establish and a bearing tree is a valuable piece of property; it is obviously unsound, therefore, to recommend the immediate destruction and replacement of all misshapen or diseased trees. What can be done, however, is to attempt to prolong their life for a few years while a replanting scheme is being carried out, such as by inter-planting with good young trees or by felling and replanting a definite amount of the field every year.

In attempting to do this, thorough attention to cultivation is of paramount importance. Drains should be opened up and deepened if necessary, and, in addition more attention should be paid to round-weeding, cutlassing, and trimming of low branches as indicated above. The dead bark of diseased trees should be carefully cut out with a sharp knife and the wound painted over with some form of wood tar or varnish. The tree thus cleaned and exposed to light and air, may have a fair chance of recovering. In California and Florida (2) trees treated in this way appear frequently to have made complete recovery and similar cases have been seen in Trinidad, although the climate is very much more humid.

It is questionable whether it is beneficial to inarch a seriously diseased tree. Obviously, in order to treat a tree in this way, it must have a reasonable length of trunk on which to work. It is useless attempting to inarch trees which have practically no trunk and fork very low. Even if the inarches 'catch', as soon as the old trunk rots away, which it is bound to do in a few years time, the tree will fall to pieces and become useless. Where the tree has a sufficient length of straight trunk to insert three or four inarches, it may be worth trying, but all low forking, badly diseased trees are better felled and new trees supplied in their place.

The author's present opinion is that inarching should not be carried out as a routine practice on all diseased trees, but only as a last resort, after all other methods of treatment have failed. Further, felling diseased trees and replanting with good young material is on the whole sounder practice than inarching. Further research is required on this subject.

It is inevitable that in the next five years the older estates will lose many of their trees through gummosis; but, if reasonable precautions along the lines indicated in this paper, are taken, it should be possible to keep all the more recent plantings practically free from the disease.

IV.—Summary.

1. A preliminary survey of the 'Marsh' grapefruit estates in Trinidad showed that gummosis was not only widespread but serious in many localities.

2. Trees budded high on sour orange stock are much less liable to attack than trees budded low on the same stock.

3. The sour orange stock used for grapefruit in Trinidad is highly resistant to gummosis.

4. Other predisposing factors in gummosis attack are: low forking of the tree, low branches touching the ground, low planting, lack of drainage and lack of proper cultivation.

5. Several possible methods of control are discussed.

V.—Acknowledgments.

The author wishes to express his grateful thanks to Dr. Briton-Jones for his help and useful suggestions, and to the owners of the several estates visited for the kindness and help which he has invariably received from them.

6. References.

(1) Briton-Jones, H. R.—*Tropical Agriculture* Vol. VIII, No. 11, p. 301.

(2) Fawcett, H. S.—Gummosis of Citrus. *Journal of Agric. Research.* Vol. 24, pp. 191-236. 1923.

THE CO-OPERATIVE SOCIETIES MOVEMENT APPLIED TO THE PROBLEMS OF THE GOLD COAST CACAO INDUSTRY.

By A. W. Paterson, N.D.A.

Introduction.

Up to the present, the most frequent use made of the co-operative movement, in connection with the improvement of peasant agriculture in the tropics has been to provide the generally heavily indebted cultivator with a cheaper source of finance than the village moneylender. An interesting experiment on new lines, however, is being tried on the Gold Coast, where a scheme to improve the quality of peasant grown and prepared produce by means of organised marketing and finance, was inaugurated in 1930-31.

The cacao industry of the Gold Coast is one of the most remarkable agricultural developments that has ever taken place in the tropics, having expanded within forty years from the export of a few pounds to a steady production of around 200,000 tons per annum. While the Gold Coast is the largest cacao producing country in the World, most unfortunately, although perhaps not entirely undeservedly, its produce is not regarded as being of a high standard of quality. The reason for this is that the cacao is all grown by peasant proprietors, each of whom prepares his own produce and sells it immediately to the agents of an exporting firm. These firms, buying ungraded produce, assume the full responsibility for the marketing process of this valuable crop from the field to the World's markets. This system, the result of the very rapid growth of the industry is one of its most serious drawbacks and a factor contributing to the present reputation of Gold Coast Cacao.

As a means of improving the quality of this cacao, some scheme of centralised preparation to secure a more regular product immediately suggests itself. Unfortunately, the local conditions do not lend themselves to such proposals owing to the absence of cheap animal transport on account of tse-tse fly, and to that feeling of suspicion generally found amongst any illiterate population.

The problem was to evolve some means of getting the individual peasant to improve his methods of preparation. In the past, all efforts in this direction beyond a certain point have failed, as the producers refused, quite naturally, to take any extra care in the preparation of their crop unless they received a higher price for such produce. The exporters maintained that while they were purchasing such large quantities, they could not offer differential prices for odd small packages of better quality.

It was in an endeavour to provide a solution of this problem that the type of co-operative society described in this article was evolved. It was assumed that a number of producers who took care in the preparation of their produce and offered for sale jointly quantities of several tons of guaranteed high quality, might expect a better price than the average.

The Co-operative Societies Ordinance was passed in 1931 and the Department of Agriculture, which has been entrusted with the development of the movement, assists groups of farmers to form themselves into co-operative societies, undertakes to examine the produce belonging to such societies and grants a certificate of quality provided it is of a purity of not less than 95 per cent.

Co-operation is a method of conducting business and money is required for such undertakings. Thus these groups of farmers had to realise that they could not hope to carry out this business without funds. Money is necessary to obtain bags for their cacao, to buy books to keep their accounts, to rent or purchase a weighing machine to weigh their produce and to rent or build a store in which to keep their produce until it is sampled and ready for sale.

Constitution of Society.

Each member on joining pays an entrance fee of one shilling which goes to the general funds of the society to provide books, &c. Any further contributions to the funds of the society are credited to the individual member's account in the form of one shilling shares. In the majority of societies before becoming a member he has to pay 6s., *i.e.*, one shilling as an entrance fee, and five shares of one shilling each. A member may purchase any number of shares provided that he does not own more than one-fifth of the total number of shares that the members of that society have subscribed. This a provision of the Co-operative Ordinance to prevent an individual obtaining control of the society by owning practically all its funds.

The system of book-keeping is quite simple and can be understood by any literate person after very little training. Each member is given a Pass Book in which all his transactions with the society are entered, there being separate pages for Share Capital, Cacao and Loans. A Minute Book to record the proceedings of meetings of the society, a Cash Book in which all the monetary transactions of the society are entered, a register of members and of shares they have subscribed, a Cacao Register in which all quantities of cacao received into the society's store are entered, and a Loan Register, are all the books that are necessary. The rulings of these books are very simple and render the book-keeping easy and facilitate checking.

At its first meeting and once annually in May, the society elects a President, a Vice-President, a Secretary and a Treasurer and a committee of not more than ten, of which, the above office-bearers are ex-officio members. A set of model bye-laws have been drawn up but societies quite frequently desire these to be strengthened and their requests if sound and reasonable are granted.

Societies are encouraged to hold regular general meetings at which the business of the society is discussed and decisions made are recorded in the Minutes of these meetings.

The societies run their own business, the officer of the Department of Agriculture, if present at a meeting, being there in a purely advisory capacity, generally assisting in the secretarial work, but he has no vote when any matter comes up for decision. These meetings would be a revelation to many of the capabilities of the local farmers, for they are generally dignified, orderly and well conducted.

Handling of Produce.

When a society is founded the members promise to ferment their cacao properly, to dry it sufficiently and to bring it to their store for bulking and certification by the Department of Agriculture and joint sale. The committee or sub-committee together with the agricultural officer examine each lot of cacao as it is brought to the store and any insufficiently dried or low quality produce is refused. After a sufficient quantity of cacao has been collected, samples are taken and analysed by the District Agricultural Officer who will grant a "Special Purity" Certificate if he finds the purity is over 95 per cent.

The produce is now offered for sale in the nearest large buying centre and a system of sealed tenders has been developed which is satisfactory both to the exporter and to the producer. The envelopes containing these tenders or offers for this produce are not opened until a stated time by the Committee of the society, who decide which, if any, they will accept. The average amount over the general local price received by co-operative societies for their higher purity cacao has been about 1s. per load—60 lb.—or between 30s. and £2 per ton.

The society deducts a certain amount, generally sixpence, sometimes three pence per load of cacao sold, in order to cover the expenses incurred and to provide for a dividend on the amounts of money subscribed by the members as Share Capital. When a society is paying its members for the cacao that has been sold members are reminded that the society needs more money to run its business and in this way the funds are gradually built up.

Progress of Movement.

That a steady rate of progress has been maintained over a period of three years and that the scale of operations is sufficiently large to afford a real test of the value of such a movement can be seen from Table I.

These figures reveal that in three years 359 new societies have been founded, that the membership has steadily increased by 7,696 and in these times of low prices that the members have subscribed £5,547 4s. 0d. in order to handle their own business.

Table I.

	No. of Societies.	No. of Members.	Share Capital Subscribed by Members.		
			£	s.	d.
1931.					
March	53	1,145	1,230	14	0
June	156	2,568	1,537	7	0
September	222	3,631	1,922	13	0
December	247	4,473	2,493	4	0
1932.					
March	278	4,973	3,056	2	0
June	303	5,421	3,445	17	0
September	360	6,843	3,959	1	0
December	380	7,625	4,708	16	0
1933.					
March	391	7,890	5,369	5	0
*June	381	7,834	6,154	4	0
September	398	8,213	6,344	5	0
December	412	8,841	6,787	18	0

The quantity of produce handled and the amounts received for it by the societies given in Table II show that this Movement is being taken seriously by the farmers.

Table II.

Year.	No. of Societies Selling Cacao.	Quantity of Cacao sold.	Revenue from sale of Cacao.		
		tons.	£	s.	d.
1930-31	40	619.2	9,892	13	0
1931-32	206	2,248.3	40,295	13	9
1932-33	357	4,176.0	69,819	10	1

Improvement of Quality.

With regard to the question of the improvement of the quality of local produce, co-operative societies have proved to be an effective measure. The average purity of the 2,248 tons cacao sold by co-operative societies during the season 1931-32 was 97.3 per cent. compared with 89.7 per cent. for all the cacao exported from the Gold Coast during the same period. In 1932-33 the figures were 4,176 tons of 97.7 per cent. purity compared with 90.1 per cent. for all the cacao exported. From these figures it can be seen that the cacao produced by co-operative societies contained 7.6 per cent. fewer defects than the average of all the cacao shipped during that year.

Secondary Organisations.

So far this article has dealt entirely with the village co-operative society selling comparatively small lots of cacao; such a system can never prove really effective, so joint selling by a number of societies agreeing to sell at the same time, is

* 17 moribund societies excluded from these returns.

being encouraged. This is taking slightly varying forms in different districts. In the case of the Oda and Offinso (Kumasi) Districts, the societies send their cacao to a central store where it is sold as a bulked parcel. In the Krobo, Koforidua and Nsawam-Kibi Districts, societies retain their cacao in their own stores but each society appoints a delegate to a Central Selling Committee with full powers to accept or reject offers for all the produce of the societies in that District. In other districts the produce of a number of adjoining societies is offered for sale at the same time, but each society decides for itself which tender shall be accepted. From this it can be seen that the aim throughout the co-operative movement is to get the members to do things for themselves, to maintain their independence and to develop an organisation run by themselves for their own benefit. When co-operative societies are in a position to offer large quantities of cacao delivered at the merchants' stores or loaded in railway vans or delivered on the beach ready for shipment, they will be able to save a very considerable portion of the charges at present incurred by merchants, with the result that the producers will get more money. The Gold Coast cacao industry is in the hands of the local farmers, they developed it and its future improvement depends on their efforts. The Government can advise and assist, but the real effort must come from the farmer himself.

The Problem of Indebtedness.

In connection with the sale of cacao by members of co-operative societies, it soon became evident that many members only sold a portion of their produce through their society. The reason for this was that they had pledged a portion of their crop by accepting advances from brokers before the time of harvest. The extent of this practice and the loss sustained by the farmers in consequence is enormous, and a recent investigation into this subject in the Oda District brought the following surprising figures to light.

In this village, there is a co-operative society of 32 members, 24 of whom during the 1932-33 season sold 392 loads of cacao through their society and received for it, after the society deducted 3*d*. per load for expenses, the sum of £178 15*s*. 9*d*. or approximately 9*s*. per load. In addition, twenty members of this society had pledged to local brokers a total of 223 loads of cacao for advances of 3*s*. to 4*s*., the average being 3*s*. 9*d*. This means that they received £41 16*s*. 9*d*. for that quantity of produce against £100 7*s*. 0*d*. which they could have obtained by selling at 9*s*. per load through their society. One must presume that these farmers required this money taken as advances, otherwise they would not have pledged their cacao at this price.

Co-operative societies have proved suitable organisations for the farmers to tackle this problem by themselves for their own benefit. A start has been made, and will continue and extend as societies accumulate more funds to enable them to grant more and more loans. A brief explanation of how this problem is being tackled will not be out of place. As soon as a society has completed its first season's sales of cacao, it usually has accumulated some money in the Bank. Before the next season, certain members who are in need of ready money apply to the society for a loan. The conditions under which the society may issue loans to its members are :—

(*a*) That the Committee is satisfied that the applicant is a suitable person to receive such a loan.

(*b*) That the applicant satisfies the Committee that the money is required for useful and necessary purposes.

(*c*) That the total indebtedness of the member does not exceed the limit fixed, usually £10, by the society's bye-laws.

(*d*) That the amount shall be repaid during the next cacao season.

(*e*) That two other members of the society will act as sureties for the borrower and sign a loan bond with him.

(*f*) That the rate of interest shall not exceed ten per cent. per annum.

The great advantage to a member who receives a loan from a co-operative society is the low rate of interest charged, viz.: ten per cent. per annum which is easily calculated as it is 2*d*. per £1 per month. To show how much could be saved to the farmers by their financing their own advances, the figures given above will be taken. If this society, which had granted ten loans amounting to £10 3*s*. 0*d*. during 1932, had been able to grant a further £40 to its members, they could have saved £56 8*s*. 6*d*. as shown below :—

223 loads of cacao at 9*s*. per load....	£100	7	0
Less interest on £41 16*s*. 9*d*. at ten per cent. per annum for six months	2	1	9
Amount members would have received had they been able to sell their cacao through their society	98	5	3
Amount members received as advances	41	16	9
Amount lost to members of the society through their accepting advances from brokers	£ 56	8	6

To show that these loans are accomp'ished facts and not merely a proposed scheme, Table III gives an analysis of the loans granted by produce marketing societies during the year 1932-33.

Table III.

No.	Amount. £	s.	d.	Per cent. of total amount.	Purpose for which granted.
455	1,075	2	0	47.4	Expenses of cultivation.
225	482	10	0	21.2	Redemption of mortgaged farms.
94	240	3	0	10.5	Old debts.
34	126	3	6	5.5	Purchase of farm or land.
33	80	5	0	3.5	Building expenses.
30	66	15	0	2.9	Funeral expenses.
72	65	16	0	2.9	Maintenance.
19	55	10	0	2.4	Education expenses.
14	49	0	0	2.2	Hospital fees.
6	23	10	0	1.4	Marriage expenses.
1	2	8	0	0.1	Purchase of firearms.
1	1	0	0	—	Court fees.
984	2,268	2	6	100.0	

The extent of these dealings and the way in which repayments have been made are most encouraging. The amount £120 12*s.* 0*d.* (five per cent.) which has become overdue is a credit to the honesty of the members of these societies and to the care with which the Committees granted these loans. The amount shown as overdue will no doubt be recovered when the Committees remind the sureties of their responsibilities. In any event, practically the whole of this sum is covered by the amounts the defaulting members have subscribed towards the funds of the society as share capital.

The remarkable development of the local cacao industry and of the Gold Coast generally, can be attributed to an active and virile rural population. If this section of the community becomes heavily indebted, there is a very grave danger that they will become careless and lethargic and the premier position of the Gold Coast in the World's cacao markets may thus be lost. To maintain and to improve the present position, the general standard of quality of Gold Coast cacao must be improved and co-operative societies can effect this in two ways. Firstly, by bulk selling of lots of higher purity for a better price, and secondly, by freeing the producer from the present system of advances, enabling him to get the full benefit of his work. This will take years of hard and unremitting work but a start has been made and the results so far justify the statement that the future of the local cacao industry depends on the efforts of the growers themselves, and that unless they can get together their efforts will be so diffuse as to be ineffective.

The difficulties that have to be overcome in establishing a system of co-operative societies in the Gold Coast are tremendous. It is necessary, first of all, to convince illiterate farmers at meetings in their own villages that a co-operative society will provide them with an organisation whereby they can help themselves. The arguments used must be sound, as no progress can be made until funds are accumulated when the value of the society to its members can be demonstrated. The co-operative society is something much bigger than a mere agency for the sale of its members' produce and a means of procuring loans at a low rate of interest; it is a system of adult education whereby farmers are taught the value of thrift, mutual help and self help.

ON THE VACCINATION OF THE TOBACCO PLANT AGAINST *THIELAVIOPSIS BASICOLA*.—C. Arnaudi.

The writer's experiments (details of which are given) at the Serotherapeutical Institute, Milan, indicated that the resistance of Beckley tobacco to *Thielaviopsis basicola* (R.A.M., xii, p. 493) may be increased by the injection of vaccines prepared from cultures of the fungus by various procedures. The most toxic vaccines are those prepared by trituration of the fungal mat and exposure to the action of ether vapour, which in 48 hours causes the material to become more fluid owing to the plasmolysing action of the ether on the cells. The ether is removed by heating to 37° to 40°C. followed by evaporation *in vacuo*, and the residue diluted with three parts of water. The fact that a similarly prepared *Pythium* vaccine induces no apparent symptoms in inoculated plants proves that the toxicity of the ether-killed *Thielaviopsis* vaccine is not due to adherent traces of ether. From the point of view of inducing immunity, however, a dry vaccine prepared as before but without dilution with water was the most effective, maintaining its efficacy for two months and acting equally well whether added to the soil in which the germinating seeds were placed or administered to seeds already germinated. The aqueous vaccines were less active when added directly to the soil. Under the conditions of the tests, the immunity acquired by absorption of these vaccines through the roots persists for some two months, a sufficient period to protect the plants during the early stages of development when susceptibility to infection is at its height. In the writer's opinion, the time is now ripe to apply the vaccine treatment against *T. basicola* on a large scale to field tobacco. Very small quantities of vaccine are needed for the treatment of a large number of seedlings, while the technique of preparation is simple and inexpensive.—(*The Review of Applied Mycology*, Vol. XIII, Pt. 5, 1934, pp. 276-277.)

A NOTE ON THE QUANTITATIVE AND QUALITATIVE CHARACTERS OF FIRST YEAR SUGAR-CANE SEEDLINGS.

By N. Craig, M.Sc.,

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Advantage was taken during the reaping of some one-hole sugar-cane seedling trials to record the refractometer brix and weight per stool of each individual stool from representative blocks of several combinations. The results herein must be regarded as essentially preliminary in character, as the area was not planted in such a manner as to enable reliable comparisons being made between the different crosses, each of which was planted in one block. All these seedlings were found in two plots each approximating 0.4 acre in extent and lying side by side, so that the soil variation is not likely to be very high, but nevertheless it does vitiate to some extent any comparison that may be made between the various crosses. In all, seedlings from thirteen crosses were examined but only eleven of these will be considered in the present article, as in two the number of seedlings examined was insufficient to give reliable figures. From 44 to 50 seedlings from each of the other crosses were examined and these were taken in one small block, of about ten stools per row in five adjacent rows, *i.e.*, in an area of about 25 feet square.

The refractometer brix was obtained by examining the juice from three cores, one from the top, one from the middle and one from the bottom of different canes in the stool. After these determinations had been made the stool was cut and weighed. From the results so obtained it was possible to calculate the standard deviation from the mean and the coefficient of variability for both the refractometer brix and the weight per stool for each cross, and also the coefficient of correlation between these two factors. These calculated results are given in the following table :—

Combination.	No. of seedlings examined.	Refractometer Brix.			Weight per Stool.			Coefficient of correlation between Refractometer and weight per stool.
		Mean Brix. %	Standard deviation.	Coef. of variability. %	Mean Weight KGS.	Standard deviation.	Coef. of variability. %	
POJ. 2878×M. 11/16	49	18.76	2.18	11.6	10.26	6.26	61.0	+0.157±0.079
M. 33/19×POJ. 2878	45	19.33	2.12	11.0	5.72	3.31	58.0	+0.258±0.072
POJ. 2878×M. 50/19	44	19.64	2.01	10.2	6.49	2.67	41.2	—0.012±0.098
M. 33/19×POJ. 2878	50	18.41	1.54	8.4	6.36	3.93	61.8	+0.234±0.070
POJ. 2878×D.K. 74	48	20.73	1.68	7.9	6.28	3.33	53.0	+0.100±0.015
R.P. 6 (G. C.)	47	19.80	1.84	9.3	5.12	3.51	68.5	+0.146±0.082
55 P.×POJ. 2878	48	20.40	1.31	6.4	5.63	2.67	47.4	+0.249±0.070
M. 33/19×M. 13/18	50	18.11	1.54	8.5	6.52	2.95	45.3	+0.112±0.081
POJ. 2878×M. 109/26	50	20.38	1.67	8.2	5.26	3.11	59.1	+0.234±0.070
POJ. 2878×87 P.	47	20.29	1.12	5.5	5.80	2.36	40.7	+0.030±0.093
POJ. 2878×Uba Marot	50	17.30	2.30	13.3	9.87	4.82	48.8	+0.057±0.087

Discussion of Results.

The most important point in these results is the total lack of correlation between the refractometer brix and the weight per stool. If we consider the cross P.O.J. 2878 by Uba Marot, we find that the female parent is a third nobilised glagah cane and that the male parent is Uba Marot, a cane of unknown origin, but almost certainly not a noble cane, which is extremely vigorous, but low in sucrose. In a cross such as this therefore it might be expected that when a seedling contains the characteristics of the wild blood of P.O.J. 2878 together with that of Uba Marot, an extremely vigorous seedling with poor juice would be obtained. If such was the case we would expect a strong negative correlation, the refractometer brix decreasing as weight per stool increases. Such however is not the case, the coefficient of correlation being + 0.057±0.087, *i.e.*, these two factors vary absolutely independently of one another. In not a single case was any significant correlation found between these two factors. This is an extremely important point to any officer engaged in cane seedling selection work as there is

a natural tendency to select the most vigorous plants, on condition that their other characteristics such as nature of growth, freedom from diseases, &c., remain equal. If a significant negative correlation had been found, it would have shown that there was a natural tendency to choose those varieties poor in sucrose.

Other points of interest may be seen in these results. The coefficient of variability of the refractometer brix varies between 5.5 per cent. and 13.3 per cent., so that the sugar content of the various individuals of any particular cross may vary fairly considerably. The coefficient of variability of the weight per stool is, however, of a much higher order, the value being from 40 per cent. to nearly 70 per cent., so that the variation in weight from stool to stool is extremely high. This variation takes into consideration all causes of variation and includes therefore soil variation. The cause with which we are particularly concerned is the inherent difference between the various varieties. However, it would appear from these figures that the chief hope of obtaining a variety of outstanding merit lies in the selection of those of high weight per stool. Naturally the ideal to be aimed at is a seedling of high weight combined with high percentage of sucrose in the cane. It has been shown elsewhere that the refractometer brix is a reliable indication as to sucrose in the juice. Consequently an outstanding cane may be looked for in a combination giving high average figures for refractometer brix and weight per stool. Moreover high coefficients of variability indicate that a certain number of the population are much above the mean and others are much below it. Thus if we had two combinations giving the same mean figures, but one had high coefficients of variation and the other low, there is a probability that the former would contain both the best and the worst varieties, on account of the greater variation. Thus if the various combinations cited above had been planted in such a way as to enable them to be compared one with the other, the combination P.O.J. 2878 by M. 11/16 would be the most hopeful combination, as the mean weight and the coefficients of variability are high, whilst the mean refractometer brix is medium.

This work is to be continued, fifty seedlings of each of ten combinations having been planted in a systematic manner so as to enable the value of the different crosses to be compared.

MISCELLANEOUS NOTES.

Further Notes on Arrowroot.—*P. H. Jones.*

The adulteration of arrowroot is here discussed. No product should be described as arrowroot which does not consist entirely of the "separated and purified starch from the rhizomes of the plant known as *Maranta arundinacea*". This definition is that laid down by the St. Vincent Government.—(*Imp. Agric. Bur., Hort. Abs.* Vol. IV, No. 2. Abs. 268, 1934.)

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Cane Molasses as a Cattle Feed. *By S. L. Singh,* B.SC. (Ag.), L.Ag., *and S. G. Singh,* B.SC. (AG.) C.D.D. (Glas.), N.D.D.

On account of the expansion of the sugar industry in this country the price of cane molasses has gone down considerably. In fact, in many places there is no market for it. Molasses is a fuel food and the suggestion is natural that pending the development of its industrial uses in the manufacture of alcohol, vinegar, &c., it could be used as a cattle feed. This is actually being done in some European countries; but in this province there is a prejudice against its use as a cattle food. It is believed by the farmers that molasses produce too much heat in the system with consequent ill-effects on the health of the animal. In the experiments described molasses was fed to farm bullocks and dairy cows. In the case of bullocks 2 lb. and 4 lb. of molasses were compared with 2 lb. of maize, the basal ration being the same in each case. Body weight of the animals was maintained quite well during the experiment.

Two pounds of molasses replaced successfully 2 lb. of maize and 0.9 lb. of mixed roughages (4.5 parts of green fodder and one part of dry fodder). The additional 2 lb. of molasses replaced only 2.5 lb. of mixed roughages. The lower efficiency of the second 2 lb. of molasses might be due to depression of the digestibility co-efficient of the basal ration as a result of feeding 4 lb. of molasses per animal per day. The experimental period lasted from 5th January to 13th April but observation on the health of the animals was continued up to the end of August. No ill-effects were observed on the health of the animals during the entire period of 239 days. The bullocks were allowed free access to common salt.

Feeding molasses to three bullocks belonging to the farm tenants was also tried. The tenants give common salt to their animals very occasionally. After feeding molasses for a fortnight the bullock began to suffer from flow of frothy saliva from their mouths. On allowing the animals free access to common salt the trouble disappeared in two days and did not recur. This observation is very important because it is possible that the farmers' belief in the ill-effects of feeding molasses may be explained as a lack of common salt in the ration.

The replacement of one pound of wheat bran in a mixed ration which was rich in protein by one pound of molasses per cow per day was successfully done without affecting the quality or quantity of milk. (Authors' Summary.).—(*Agriculture and Livestock in India,* Vol. IV, Pt. II, 1934, pp. 164-5.)

* * *

Origin of the name "Woolly Pyrol."

A correspondent would be glad to trace the origin of the name "Woolly Pyrol," applied in the West Indies to *Phaseolus mungo.* This is the 'urid' of India. If any reader is able to give information on this point, the Editor would be grateful to hear from him.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Animal Charcoal (Boneblack) of Double the Usual Decolorizing Power.—*A. Hinze.*

This writer claims to have invented a process of activating char, and of revivifying it, the latter operation being applied *in situ* in the filters. Kilning (it is said) is replaced with a chemical treatment, the nature of which is not divulged. In it chlorides form the last decomposition product, and these being slightly absorbed by the char can be easily washed out. By means of this activation process a char is produced which has double the usual decolorizing power of German char and regeneration brings it up to at least 80 per cent. of its original value. Some figures for decolorizing tests made with the new process are here given :—

	Decolorization per cent.
1. "Carboraffin", 0.5 grm. per 100 c.c. of sugar liquor	78
2. Char, new, activated by the Hinze process, 1 grm. per 100 c.c. of liquor	62
3. Char, new, usual commercial product, 1 grm. per 100 c.c.	30
4. Char, as used in test 2, regenerated by the Hinze process, 1 grm. per 100 c.c., after the first regeneration ..	52
5. Ditto. after the second regeneration, 1 grm. per 100 c.c.	55

This process has now been tested out on the large scale in five factories and refineries in Germany, and with satisfactory results. It is said that the plant required is not costly initially, is economical to operate, and does not require much space.—(*Int. Sugar Jr.*, Vol. XXXVI, No. 425, 1934, p. 196.)

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Effect of Stubble Shaving on Cane and Sugar Yields.—*G. Arceneaux.*

The practice of shaving cane stubble has long been more or less general in Louisiana, the object being to reduce the cost of hoeing and to facilitate cultivation. During the three years 1930-32 the practice was subjected to field study at the Hoaum Station, where the stubble of the three principal cane varieties was shaved one inch below the ground surface at dates between January and April.

The effect of shaving varied somewhat with the variety. With P.O.J. 36-M the results on the whole were unfavourable. In some cases there was no appreciable difference; in others the sugar yield was reduced as much as 800 lb. per acre. In one year shaving of Co. 281 resulted in slightly higher yields of both cane and sugar, but in other years there were definite and in some cases large decreases in cane and sugar yield. Shaving C.P. 807 gave consistently unfavourable results; reductions in the yield of cane per acre ranging from 6 to 12 tons were common.

Averaging the results of the entire series of experiments, the effects of stubble shaving must be regarded as generally detrimental. The reason appears to be that the shaving operation involves cutting off some of the viable buds, and also a sacrifice of considerable growth, particularly in the case of early germinating canes like C.P. 807. This perhaps explains why this variety suffers more from shaving than the others.

For the same reason it appears that the shaving is apparently less detrimental when done in January and February than when done in March, when considerable growth has started. April shaving is even more harmful than March shaving. In view of these facts, any saving in labour achieved by shaving is obtained at a sacrifice in yield.—(*Facts about Sugar*, Vol. 29, No. 3, 1934, p. 94.)

* * *

Comparison of Coimbatore Canes with Uba.—*H. H. Dodds and P. Fowlie.*

Co. 213, 214, 281 and Uba canes were planted on a flat loam soil very stiff clay subsoil, this soil being of poor agricultural quality, and subject to severe drought. Under these circumstances Co. 281 proved decidedly superior to Uba and the other two Coimbatore varieties, and this superiority was carried over into the first ratoon crop. This ratoon crop had 61.64 inches of rain over 22 months' growth—4.83 inches during the first four months and 10.08 inches over the last five months; under these conditions 23.68 per cent. of Uba was dead at harvest, 19.90 per cent. of Co. 213, 2.12 per cent. of Co. 281, and none of Co. 214; this last variety, however gave much the smallest yield of the four. Co. 281 is extremely resistant to streak disease and on the whole appears to be a valuable variety for South African conditions.—(*Facts about Sugar*, Vol. 29, No. 7 1934, p. 243.)

* * *

Experiments with Coimbatore Canes.—*W. E. Cross.*

Among the Coimbatore canes (205, 213, 281 and 289) that have been subject to extensive trial in Tucuman, only Co. 281 shows any degree of promise under Tucuman conditions. Co. 210 is a complete failure on account of its susceptibility to mosaic; Co. 223 is a prolific stooler, but its sucrose content is low: Co. 290 also gives a large yield of cane, but its sucrose content is also small, and the same applies in larger or smaller degree to Nos. 270, 272 and 284.—(*Facts about Sugar* Vol. 29, No. 7 1934, p. 243.)

THE EDITOR requests that any subscriber who fails to receive *Tropical Agriculture* regularly should communicate with him immediately in order that the matter may be rectified.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Citrus Fruit Juices for Bottling.

(1) The precautions to be taken in the bottling of carbonated citrus fruit juices for direct consumption are fully set out by J. H. Toulouse of the American Bottlers of Carbonated Beverages Company of Washington, in an article that appeared in *Industrial and Engineering Chemistry*, July 1934, Vol. 26, No. 7, pp. 765-768. Fruit juices have recently been re-introduced with great success as flavourings for carbonated beverages, because of improvements in the technique of their preparation. Most of the flavourings used nowadays are still derived from natural sources; synthetic chemical flavouring substances are only rarely employed. The chief natural materials are rind oils and pulp juices of oranges, lemons and limes and extracts of vanilla beans, ginger roots, capsicum pods, sarsaparilla, and of many other herbs, roots, barks, leaves and seeds.

Citrus juices used as flavouring media, have frequently proved unsatisfactory because of the effects of extensive chemical deterioration, particularly oxidation, on their quality. Contamination by yeasts, moulds and bacteria have also spoiled the raw materials.

The cost of the materials used in the manufacture of carbonated beverages amounts to between 30 and 40 per cent. of the total cost, the residue paying for labour, selling and delivery. In order to keep down costs, only a limited amount of citrus flavourings derived from pure juices can be employed. Thus experience has proved that an increase of only one cent over the established retail price of five cents per bottle for carbonated citrus beverages will not be tolerated by the public. In one locality, such an increase in price caused by a 20 per cent. sales tax, forced 90 out of 160 bottling plants out of business.

Citrus juices differ widely in their contents of sugars, salts, acids and aromatic oils, and must be carefully blended and standardized before utilisation. Some figures for average composition of citrus flavoured carbonated beverages are given in the following table:—

	Sugar (%) Brix)	Citric acid (g. per litre).	Vol. of gas per unit vol. of beverage.	Acidity (pH value.)
Orange ..	13.4	1.93	2.3	3.4
Lemon ..	11.2	1.20	3.2	3.1
Lime ..	11.1	2.28	3.7	2.9

Regional preference regarding the demand for beverages of different degrees of sweetness, acidity, flavour and colour is well established in the trade, and great importance is attached to this factor in connection with sales.

The handling of citrus juices intended for the bottler involves attention to many important features, among which are (*a*) storage away from heat and light, (*b*) sterilisation of bottles, (*c*) purity of materials, and (*d*) standardization of composition and quality. Spoilage caused by micro-organisms is mainly due to yeasts, since the acidity of the juices prevents the growth of most bacteria. Certain antiseptics, such as sodium benzoate, are often added to citrus juices in order to destroy yeasts. The most serious deterioration, however, is caused by oxidation. Care must therefore be exercised to exclude air from the juice containers, and to prevent the access of traces of substances, such as chlorine, chlorinated cresols and phenols, which promote or accelerate oxidation. Such substances occasionally contaminate the water used to dilute the juices, or to cleanse utensils and containers, necessitating the installation of water purifying equipment.

(2) The subject of oxidation is separately dealt with by J. H. Toulouse in an article following the one reviewed above, in the same journal, pages 769-770, in which the effects of temperature, long storage and micro-organisms are described, and methods for their measurement are indicated. Some of the undesirable effects may be eliminated by proper adjustment of the bottling machinery, whereby the greater part of the air contained in the citrus beverage is driven off during filling.

(3) The preservation of orange juice by elimination of air and by pasteurisation is discussed in a third following article, by H. W. von Loesecke, H. H. Mottern and G. N. Pulley of the U.S. Citrus Products Station in Florida. Orange juice is particularly prone to deterioration in flavour, especially the canned product. Details of a successful experimental procedure are fully presented in the article cited; the following summary indicates the main features.

The fruits are halved and slowly reamed. The juice is at once de-aerated, then pasteurised at 96°C. (205°F.) for not more than five seconds. It is introduced into the container cans at 76° to 82° C. (170° to 180°F). and sealed under vacuum, but at a pressure sufficiently high to prevent boiling. When canned under these conditions, the juice may be stored at 16°C. (60°F.) for ten months without losing its flavour. Addition of sugar syrup to raise the sugar-acid ratio to 15 enhances the keeping qualities.

* * *

Spanish Potash in 1933.

Spain assumed an important position in world potash trade during 1933, exports having increased to 198,656 metric tons, as compared with 65,989 tons in 1932 and 25,649 tons in 1931. From 1928 to 1932, the United States was the chief foreign buyer of Spanish potash, but in 1933 the Netherlands occupied first place with 42 per cent. of the total, followed by United States with 26 per cent., and Japan with seven per cent.—(*Ind. & Eng. Chem., News Edition*, Vol. XII, No. 8, 1934, p. 148.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.).

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
28th June	4	7½	8	7½
5th July	4	10½	8	9
12th July	4	10½	8	6
19th July	4	10½	8	6¾
26th July	4	10½	8	7½
2nd August	4	9	8	7½
9th August	4	9	8	7½
(*12th August*, 1933)	6	6¾	11	3

The improvement in the tone of the market, both in America, due to the prospect of an increase in the Cuban preference, and in the United Kingdom, due partly to the unfavourable weather conditions in the beet areas of Europe, was only short-lived and prices are now following a much quieter tendency. Stocks in the United Kingdom have for some time past been steadily reduced, and the present total whilst providing ample reserve for all ordinary demands is some way below that of last year. A further reduction in supplies is not improbable.

* * *

COFFEE.—No improvement in the demand for spot supplies of coffee can be recorded, although the small part sold realized about steady rates. Costa Rica, foreign cleaned, bold grey-greenish, sold from 79*s.* to 102*s.* 6*d.* per cwt. Kenya bold grey-greenish, at 82*s.* 6*d.* Brazilian kinds were dull and easier; superior Santos quoted from 43*s.* f.o.b.

* * *

BANANAS.—A fairly good business has been done in Jamaicas, but the demand has been affected to some extent by the large supplies of soft fruit. There has been a sharp decline in trade to the Continent owing to the political and financial troubles. Today's prices (per ton to wholesalers) are as follows:—

	Delivered London.		*Nearest Station Provinces.*	
	£	s.	£	s.
Jamaica Producers	20	5	20	0
Elders & Fyffes	19	5	19	0

Brazilians are in good demand, and the price is unchanged at £18 per ton, delivered nearest station. (*West India Committee Circular*, 5th July.)

* * *

LIME PRODUCTS.—*Lime Oil.*—There are sellers of Handpressed at 32*s.* 6*d.*, but no demand. Distilled is neglected and new crop offers are rather checking business. *Lime Juice.*—In Concentrated there are buyers at £4 10*s.*; Raw is firm at 2*s.* 6*d.* to 2*s.* 8*d.*—(*West India Committee Circular*, 5th July.)

COCOA.—There is very little change to report in the cocoa market since last publication and demand from Europe is negligible. In some directions buyers show complete indifference which proves that manufacturers are not inclined to anticipate their requirements, preferring to wait until manufacturing is in full swing. It is impossible to say what course prices will take, the market indications, which years ago could be taken as a guide, are no longer reliable, in fact with the continual Political disturbances, one's working is put right out of gear.—(*By Courtesy of the Cocoa Planters' Association of Trinidad Ltd.*)

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows:—

	d.
27th June	6 3-4
4th July	6 3-16
11th July	7 3-16
18th July	7 1-16
25th July	7 1-8
2nd August	7 1-8
8th August	7 3-8
(*12th August*, 1933)	3 29-32

The market has continued firm in spite of inactive days, and the price has even advanced slightly. Any slight weakness in tone seems to bring in fresh buying from one source or another, and rubber at present prices is considered a good investment. The steadiness of the market can thus be ascribed to the extreme reserve on the part of sellers, and to a growing confidence in the commodity.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association:—

	American Mid.	*Egyptian F.G.F. Sakel.*
29th June	6.84	8.35
6th July	6.66	2.28
13th July	6.99	8.43
20th July	7.17	8.66
27th July	6.88	—
3rd August	7.06	—
10th August	7.42	—
(*11th August*, 1933)	5.90	7.96

The recent further upward trend in the market was due to the publication of the acreage estimate by the United States Government of 28,024,000 acres, fully a million acres less than expected, and 31.4 per cent. lower than last year's estimate. Owing to the very severe drought which continues over the Belt the ultimate outturn is expected to be well below the estimate. The Egyptian market is slightly steadier but awaits the lead of American. About 50 bales of West Indian Sea Island have been sold, including Montserrat and St. Vincent at 14½*d.* to 15*d.*